Feeding Activity, Rate of Consumption, Daily Ration and

Prey Selection of Major Predators in the John Day Pool

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FEEDING ACTIVITY, RATE OF CONSUMPTION, DAILY RATION AND PREY SELECTION OF MAJOR PREDATORS IN THE JOHN DAY POOL.

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ABSTRACT

This report summarizes activities in 1983, the second of a five year study to determine the extent of predation by resident populations of native and introduced fishes on juvenile salmonids in John Day Reservoir. As in 1982, catches of northern squawfish (Ptychocheilus oregonensis) were highest in areas adjacent to dams: percent by weight of juvenile salmonids in the diet was up to 89.7% higher in these areas. Catches of walleyes (Stizostedion vitreum vitreum) were greatest outside restricted zones (700-900 m above and below the dams) in spring of both 1982 and 1983. P boercent by weight of juvenile salmonids in walleyes collected in 1983 was generally higher at McNary tailrace and lower at Irrigon and John Day tailrace than in 1982. Smallmouth bass (Micropterus dolomieui) was the most common species collected and contained few salmonids in 1983. Results of the diet analysis for channel catfish (Ictalurus punctatus) varied substantially between 1982 and 1983 as a result of eliminating the John Day River sampling transect and increasing sampling effort at McNary tailrace, Irrigon, and John Day tailrace. The beach seine and boat electroshocker were effective gears for evaluating prey abundance. Data obtained to estimate relationships between fork length of juvenile chinook salmon (Oncorhynchus tshawytscha) and other body or bone measurements indicated that body length predicted fork length best, followed by cleithrum, dentary, and oopercle measurements. Digestion over time was estimated for 162 northern squawfish fed juvenile salmonids at temperatures ranging from 10 to 20 C.

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INTRODUCTION

The Seattle National Fishery Research Center of the U.S. Fish and Wildlife Service is conducting a five year investigation funded by the Bonneville Power Administration to determine the extent of predation by northern squawfish (Ptychocheilus oregonensis), walleye (Stizostedion vitreum vitreum), smallmonth bass (Micropterus dolomieui), and channel catfish (Ictalurus punctatus) on juvenile anadromous salmonids in John Day Reservoir (Lake Umatilla). Overall study objectives are:

1. Determine the food habits, rate of consumption, daily ration, and feeding activity of major predators.
2. Determine the patter" of prey selection of major predators es a function of time and reservoir habitat.
3. Estimate the rate of gastric evacuation of major predators.

I" 1983, the second year of study, there were five sub-objectives:

A. Obtain field data needed to estimate consumption and describe food habits of northern squawfish, walleyes, smallmouth bass, and channel catfish during the smolt outmigration.

B. Describe apparent abundance of northern squawfish, walleyes, and smallmouth bass.

C. Determine effective gears to use in estimnting prey abundance and describe distribution patterns of Prey fishes.

D. Develop regression equations to describe relations between fork length of juvenile salmonids and other body or hone measurements.

E. Obtain data needed to develop regression equations to describe relationships between percent digestion and time for northern squawfish.

The stomach contents data (sub-objective A) will he used to estimate consumption for the average predator. The contribution of both juvenile salmonids and other prey fish to average daily consumption will he identified. The descriptive food habits analysis will he used to support conclusions drawn from the quantitative analysis.

Apparent abundance estimates (sub-objective B) are included to provide general information on predator density in areas sampled. Specific data on predator abundance and population dynamics are available through research being conducted by the Oregon Department of Fish and Wildlife.

The gear effectiveness data (sub-objective C) will he used to select gears to estimate the apparent abundance of prey fish found in John Day Reservoir. The apparent prey abundance and predator food habit data will then be compared to determine if a pattern of prey selection exists.

The body length versus bone Length regressions (sub-objective D) will he used to back-calculate the original body length of partially digested prey fish found in the stomachs of predators. These data will be converted to weight andused in estimates of food consumption.

Regression equations of northern squawfish digestion versus time (sub-objective E) will he used to estimate the time of ingestion of each prey fish found in stomachs. These data will then he used in calculating food consumption.

METHODS

Food Habits

Food consumption of predators was monitored by sampling three diel periods at each of four stations (Gray et al. 1983) during four time periods (Table 1). Boat electroshocker, bottom trawls, and gill nets were used to collect predatory fish. Sampling effort with each gear was varied to adjust for differences in species composition and morphometric features at each station. A boat electroshocker was used at all stations. Designated transects were shocked for 15 minutes once every 1.5 hours to maintain comparability with sampling conducted in 1982. Bottom trawls (9 m semi-ballon and 10.5 m otter) were used at McNary tailrace. Duration of tows ranged from 4 to 18 minutes ($\bar{x}$ = 11 minutes). Bottom gill nets were used at all stations except John Day forebay. Multifilament mesh gill nets measuring 60 by l.R m with either 12.7 cm or 15.2 cm stretch mesh were set for up to one hour in water depths ranging from one to 15 m.

Techniques used to process predatory fish and analyze stomach contents were similar to those used in 1982 (Gray et al. 1984) with four exceptions: 1) predator length was measured to fork rather than total length ($\pm$ 1.0 mm); 2) smallmouth bass and northern squawfish less than 100 and 150 mm, respectively, were preserved whole; 3) whole stomachs were injected with 10% formalin; and 4) body length (total,

Table 1. Dates during which samples were collected at each station, John Day Reservoir and tailrace, 1983.

McNary tailrace	Irrigon	John Day forebay	John Day tailrace
Apr 4 - Apr 21	Apr 5 - Apr 22	Apr 19 - May 11	Apr 14 - Apr 20
May 5 - May 20	May 6 - May 24	May 23 - Jun 8	Jun 1 - Jun 22
Jun 4 - Jun 22	Jun 11 - Jun 17	Jun 21 - Jul 1	Jul 5 - Jul 21
Aug 1 - Aug 25	Aug 3 - Aug 25	Aug 17 - Sep 2	Aug 31 - Sep 23

fork, standard, or nape to tail length) of prey fish found in predators was measured to the nearest mm, or bone length (cleithrum, pharyqeal tooth, opercle, dentary, or hypural) was measured to the nearest 0.16 mm, depending upon condition of vertebrae.

Apparent Abundance of Predators

Apparent abundance of northern squawfish (≥250 mm), walleye, and smallmouth bass was estimated from catch per effort data collected with the boat electroshocker. The standard unit of effort was one 15 minute transect. Walleye and smallmouth bass catches were summarized by station and time period. Northern squawfish catches were grouped by restricted zone (700-900 m above and below dam) and non-restricted zone for each station and time period.

Apparent Abundance of Prey Fishes

To determine the most effective gears for estimating apparent abundance of prey fishes (<250 mm), backwater habitats at McNary tailrace (Plymouth Slough) and main channel habitats at Irrigon, John Day forebay, and John Day tailrace were sampled with boat electroshocker, heach seine, bottom gill nets, and minnow traps during each sample period (Table 1). Three boat electroshockinq transects were sampled after sunset at each station for 15 minutes.

Beach seining was conducted using a 30.5 x 2.4 m seine constructed of 6.4 knotless nylon mesh, with a 2.4 x 2.4 x 2.4 m hag. A standard seine haul was made by setting the seine perpendicular to the shoreline and towing it back to shore in a quarter circle. Three seine hauls were conducted after sunset at each station except John Day forebay where sampling sites were limited.

Multifilament mesh bottom gill nets used to sample prey fishes measured 7.6 x 2.6 m with either 1.9 cm or 2.5 cm stretch mesh, TWO gill nets, one of each mesh size, were fished at three locations at each station. Gill nets were set perpendicular to shore three hours prior to sunset and lifted six hours later.

Minnow traps, made of h.4 mm galvanized steel mesh and measuring 44.5 cm long by 22.9 cm in diameter were baited and set in gangs of three at three locations at each station. Traps were set in 2 to 3 m of water three hours prior to sunset and lifted six hours later.

Techniques used to enumerate catches varied according to the number of prey collected. When fewer than 50 fish of a particular species were collected all were counted and measured to fork length (+ 1.0 mm). If more than 50 fish of a species were collected, a random subsample of 50 was measured and the remainder counted; in rare instances when catch of a species exceeded 1000 fish, A volumetric subsample was enumerated.

Data were analyzed to estimate prey selectivity of each gear, compare abundance estimates by gears, and describe distribution patterns. Gear selectivity was evaluated for a species when "ore than 150 individuals were collected with all gear types. Gear selectivity among taxa was determined by comparing catch of each gear with that of all other gears. Gear selectivity within a taxon was evaluated by comparing length frequency distributions of each taxon by gear type. Gears that consistently collected the widest range of taxa and lengths within a taxon were considered to be the least selective.

To compare catches from gears that were least selective in collecting various taxa and lengths of prey fishes, each taxon was ranked in order of abundance by time and station for effective gears. Mean ranks of abundance were then calculated for effective gears by station for each taxon.

Body Length Regressions

Juvenile chinook salmon (*Oncorhynchus tshawytscha*) used to develop relations between fork length and other body or hone measurements were collected in the field during regular sampling or from local hatcheries. Samples were individually marked and frozen until analyzed. In the laboratory, total, fork, standard, and nape to tail length, and bony part lengths ($\pm$ 0.16 mm) were measured and fish were weighed ($\pm$ 0.1 g). Sony parts were obtained by placing prey fish in boiling water until the flesh could he easily removed hut the skeleton remained intact (30 to 60 seconds). Bony parts used to calculate fork length were selected during gut content analysis of field samples, using the criteria that they be resistant to digestion and uniquely identifiable. Small hones were measured using an ocular micrometer at 8X power; larger hones were measured with a hand caliper.

Northern Squawfish Digestion Experiments

Northern squawfish (>250 mm) used to determine relation between digestion and time were collected from John Day tailrace using a boat electroshocker. Experiments were conducted in 1.52 m wide by 1.37 m high circular tanks at the Willard Field Station using a range of temperatures (10, 15, 20 C), prey Sizes (4-10, 15-30, >35 g), and predator sizes (250-349, 350-400, >400 mm) commonly encountered in John Day Reservoir.

Digestion trials at each temperature were initiated following a two week acclimation period in which test fish were fed *ad libitum* on live juvenile salmonids. The fish were then starved for 72 to 96 hours, sorted by fork length into groups, and fed juvenile salmonids of known weight (blotted weight to the nearest 0.1 g). To identify northern squawfish that had eaten, each juvenile salmonid was tagged with stainless steel wire that could be detected in the predator's stomach with a. metal detector. The fish in each compartment were checked at half-hour intervals to determine whether feeding had occurred. Northern squawfish that had fed were removed from the tank after preselected time intervals. At the start of experimentation, northern squawfish were removed at successive two hour intervals after feeding until 90% digestion of prey occurred. This was later modified to the apparent speed of digestion, with predators fed small prey sampled at one hour intervals and those fed medium prey at 15 and 20 C sampled at combinations of one or two hour intervals. After removal, fish were anesthetized, weighed ($\pm$ 1.0 g), measured to fork length ($\pm$ 1.0 m), and the digestive tract was removed. The gut was then opened, position of the food item noted, the food item removed, blotted, and weighed ($\pm$ 0.1 g). After at least two weeks in a 10% formalin solution, the food items were reweighed. The weight of the partially digested salmonid divided by the original weight provided an estimate of percent digestion.

RESULTS

Food Habits of Northern Squawfish

Digestive tract contents of 1,642 northern squawfish, collected from April to September 1983, were analyzed. Northern squawfish examined ranged in length from 31 to 586 mm (2 = 354 mm). Thirty-five percent (568) of the digestive tracts contained no food.

Overall, northern squawfish examined in 1982 and 1983 consumed a wide variety of food items hut fish dominated by weight (Table 2). The importance of fish in the diet increased directly with respect to predator length, hut at an irregular rate (Fig. 1). No fish were found in northern squawfish <100 mm in length. Fish comprised about 10% of the diet of northern squawfish 100-199 mm in length. Fish consumption increased to 37.1% among northern squawfish between 200 and 249 mm, primarily as a result of feeding on American shad (*Alosa sapidissima*) in John Day forebay and tailrace during late August and September. Percent by weight of fish in the diet of northern squawfish between 250 and 349 mm was similar to fish between 200 and 249 mm, hut these fish fed on a diverse array of fish taxa throughout the sampling season. The importance of fish in the diet increased markedly among northern squawfish ≥350 mm in length, ranging from 68.4% to 100%. Importance of salmonids to the diet also increased among northern squawfish ≥350 mm in length, although none were found in two stomachs examined from the 550-599 mm length group.

Table 2. Percent occurrence and weight of food items in digestive tracts of northern squawfish ranging in length from 32 to 524 mm in 1982 and 31 to 586 mm in 1983, John Day Reservoir and tailrace, April 4 to September 23, 1982 and 1983. Sample sizes and numbers of empty digestive tracts were 953 and 282, respectively, in 1982 and 1,642 and 568, respectively, in 1983.

Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
MOLLUSCA	2.6	5.9	2.5	4.3
Pelecypoda				
Corbicula manilensis	2.5	5.8	2.5	4.3
Gastropoda	0.1	0.3	<0.1	<0.1
CRUSTACEA	27.6	35.7	9.5	15.8
Cladocera	2.2	0.0	<0.1	0.0
Mysidacea	0.0	0.2	0.0	<0.1
Isopoda	0.9	0.0	<0.1	0.0
Amphipoda	16.9	26.4	0.8	3.0
Anisogammarus spp.	2.8	2.6	<0.1	<0.1
Corophium spp.	15.7	23.6	0.8	3.0
Unidentified Amphipoda	0.2	2.1	<0.1	0.1
Decapoda				
Pacifastacus leniusculus	10.1	11.8	8.7	12.7
INSECTA	39.5	27.5	17.5	2.9
Collembola	0.0	0.1	0.0	<0.1
Ephemeroptera	11.3	8.7	0.5	0.2
Odonata	0.0	0.4	0.0	<0.1
Orthoptera	0.4	0.3	<0.1	<0.1
Dermaptera	0.2	0.1	<0.1	<0.1
Plecoptera	0.0	0.3	0.0	<0.1
Hemiptera	2.7	2.5	<0.1	<0.1
Homoptera	2.3	2.6	<0.1	<0.1
Coleoptera	7.5	6.2	0.3	0.2
Trichoptera	5.4	1.0	0.1	<0.1
Lepidoptera	0.4	0.9	<0.1	0.1
Diptera	15.0	12.7	0.5	0.5
Hymenoptera	12.4	7.1	15.4	0.8
Unidentified Insecta	11.5	11.5	0.6	1.1
AGNATHA				
Petromyzontidae	0.0	0.6	0.0	0.2
OSTEICHTHYES	18.8	22.7	69.6	75.9
Clupeidae				
Alosa sapidissima	4.5	4.3	18.4	6.3
Salmonidae	7.2	12.1	34.1	56.6
Oncorhynchus tshawytscha	0.8	0.3	8.7	0.8
Salmo gairdneri	0.2	0.7	3.4	8.9
Unidentified Salmonidae	6.1	11.3	22.1	46.8
Cyprinidae	0.8	0.7	4.8	3.3
Acrocheilus alutaceus	0.6	0.2	4.3	1.4
Mylocheilus caurinus	0.1	0.3	0.2	0.4
Ptychocheilus oregonensis	0.1	0.2	0.3	1.5
Catostomidae				
Catostomus spp.	1.2	0.7	6.4	1.2
Percopsidae				
Percopsis transmontana	0.2	0.6	0.0	0.6
Centrarchidae	0.7	0.1	1.3	0.1
Cottidae				
Cottus spp.	2.3	3.7	3.5	7.6
Unidentified non-Salmonidae	1.5	0.2	0.7	0.1
Unidentified Osteichthyes	1.9	0.7	0.5	0.1
OTHER FOOD	6.0	7.1	0.8	0.9

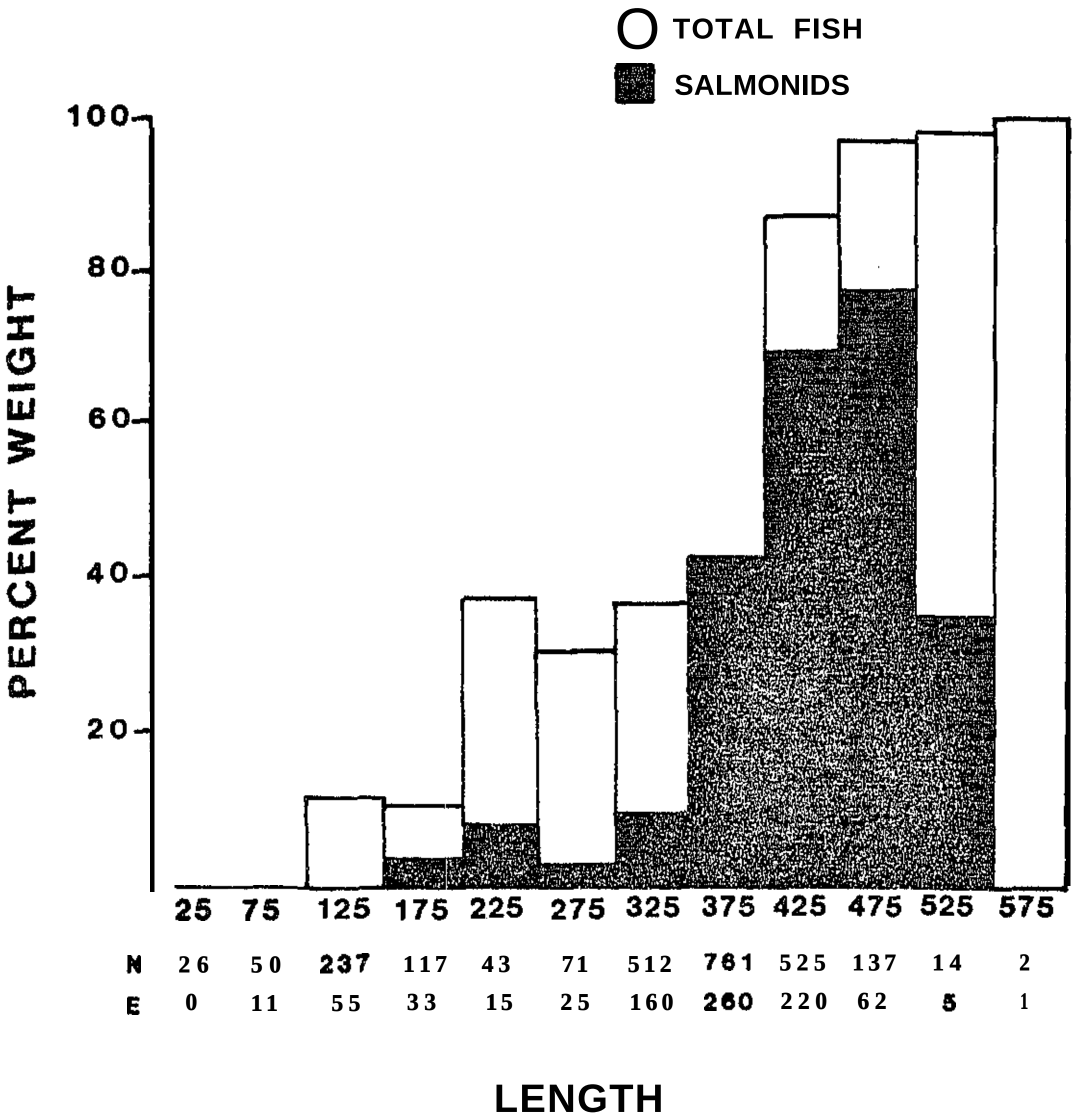

Figure 1. Percent weight of total fish and salnonids versus northern squawfish length, John Day Reservoir and tailrace, 1982 and 1983. Lengths are midpoints of 50 mm intervals. N = number of digestive tracts analyzed; E = number of empty digestive tracts.

To provide a "ore meaningful description of food habits by date and station, northern squawfish samples were divided into three length groups for analysis: small (<100 mm), medium (>100-249 mm), and large (≥250 mm). Northern squawfish less then 100 mm in length were combined because they did not consume fish. Northern squawfish from 100 to 249 mm were grouped because they represent a transitory stage between northern squawfish that feed primarily on invertebrates and those that feed primarily on fish.

Food habits of small northern squawfish were not analyzed by date because of inadequate sample sizes but it was apparent that these fish fed primarily on insects and crustaceans at all stations (Table 3). Insects contributed more than 65% to the weight of food consumed at McNary tailrace in both years and at John Day forebay in 1982 (no 1983 sample). The percent by weight of crustaceans (86.9%) was hiqher than for insects (13.1%) at Irrigon in 1983 while the opposite occurred in 1982. Similarly, crustaceans dominated by weight at John Day tailrace in 1982, hut were less important than insects in 1983.

Crustaceans and insects were principal food items in medium-sized northern squawfish by weight (Tables 4-7), although northern squawfish as small as 104 mm in 1982 and 109 mm in 1983 consumed fish. Salmonids were found in fish as small as 181 mm in 1983, but contributed little by weight except at Irrigon.

Foods consumed by medium northern squawfish varied somewhat between sample locations. At McNary tailrace, insects and crustaceans accounted for more than 63% of the food consumed by weight in all sample periods except June of 1983 (44.7%) when salmonids contributed

Table 3. percent occurrence and weight of food items in digestive tracts of small northern squawfish (<100 mm) by station, John Day Reservoir and tailrace, April 4 to September 23, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Station	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
McNary tailrace					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 28, 4)	Crustacea	39.3	5.6	18.2	7.6
(1983 - 18, 1)	Insecta	78.6	88.9	65.3	75.8
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	10.7	44.4		16.7
Irrigon					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 4, 0)	Crustacea	50.0	20.0	22.4	86.9
(1983 - 10. 4)	Insecta	50.0	50.0	77.6	13.1
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	0.0	0.0	0.0	0.0
John Day forebay					
	Mollusca			0.0	
(1982 - 5, 1)	Crustacea	0.0		0.0	
(1983 - 0, 0)	Insecta	80.0	NS[a]	98.2	NS
	Osteichthyes	0.0		0.0	
	Salmonidae	0.0		0.0	
	Other food	20.0		1.8	
John Day tailrace					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 7, 1)	Crustacea	42.9	25.0	76.3	2.7
(1983 - 4, 0)	Insecta	28.6		2.6	21.6
	Osteichthyes	0.0	0.0	0.0	0.0
	salmonidae		0.0	0.0	0.0
	Other food	42.9		21.1	

a NS = no sample

Table 4. percent occurrence and weight of food items in digestive tracts of medium northern squawfish (100-249 mm) by sample period, McNarytailrace, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 4 - Apr 21					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 11, 4)	Crustacea	45.5	33.3	50.0	9.5
(1983 - 6, 1)	Insecta	18.2	83.3	47.4	54.3
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	18.2	33.3	2.6	36.2
May 5 - May 20					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 13, 4)	Crustacea	15.4	50.0	21.1	58.3
(1983 - 10, 3)	Insecta	61.5	50.0	73.8	38.5
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	15.4	40.0	5.2	3.2
Jun 4 - Jun 22					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 11, 3)	Crustacea	18.2	26.1	5.3	11.8
(1983 - 23, 8)	Insecta	72.7	52.2	94.7	32.9
	Osteichthyes	0.0	4.4	0.0	24.2
	Salmonidae	0.0	4.4	0.0	24.2
	Other focd	0.0	26.1	0.0	31.2
Aug 1 - Aug 25					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 34, 12)	Crustacea	26.5	42.9	9.1	82.2
(1983 - 7, 2)	Insecta	47.1	42.9	84.3	17.5
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	8.8	14.3	6.6	0.3

Table 5. Percent occurrence and weight of food items in digestive tracts of medium northern squawfish (100-249 mm) by sample period, Irrigon, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty <digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 5 - Apr 22	Mollusca	0.0	0.0	0.0	0.0
(1982 - 8, 2)	Crustacea	50.0	17.7	7.7	6.6
(1983 - 17, 2)	Insecta	37.5	88.2	19.6	93.2
	Osteichthyes	0.0	5.8	0.0	6.9
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	25.0	27.5	72.7	3.3
May 6 - May 24	Mollusca	0.0	0.0	0.0	0.0
(1982 - 11, 1)	Crustacea	54.h	33.3	13.5	32.9
(1983 - 12, 3)	Insecta	54.6	58.3	9.7	55.8
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	54.6	25.0	76.8	11.3
Jun 11 - Jun 17	Mollusca		13.3		1.0
(1982 - 0, 0)	Crustacea		66.7		21.7
(1983 - 15, 1)	Insecta	NS[a]	60.0	NS	14.5
	Osteichthyes		13.3		62.6
	Salmonidae		6.7		61.2
	Other food		2h.7		0.2
Aug 3 - Aug 25	Mollusca	3.2	5.7	0.5	1.5
(1982 - 31, 8)	Crustacea	32.3	60.0	2.0	32.5
(1983 - 15, 4)	Insecta	51.6	73.3	95.7	64.1
	Osteichthyes	3.2	0.0	0.4	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	25.8	20.0	1.4	1.9

[a] NS = no sample

Table 6. Percent occurrence and weight of food items in digestive tracts of medium northern squawfish (100-249 mm) by sample period, John Day forebay, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 19 - May 11					
	Mollusca				
(1982 - 0, 0)	Crustacea				
(1983 - 0, 0)	Insecta	NS[a]	NS	NS	NS
	Osteichthyes				
	Salmonidae				
	Other food				
May 23 - Jun 8					
	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		100.0		99.3
(1983 - 1, 0)	Insecta	NS	100.0	NS	0.5
	Osteichthyes		0.0		0.0
	Salmonidae		0.0		0.0
	Other food		100.0		0.2
Jun 21 - Jul 1					
	Mollusca	0.0		0.0	
(1982 - 1, 1)	Crustacea	0.0		0.0	
(1983 - 0, 0)	Insecta	0.0	NS	0.0	NS
	Osteichthyes	0.0		0.0	
	Salmonidae	0.0		0.0	
	Other food	0.0		0.0	
Aug 17 - Sep 2					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 1, 0)	Crustacea	100.0	20.0	2.5	22.7
(1983 - 5, 0)	Insecta	100.0	80.0	97.5	18.0
	Osteichthyes	0.0	80.0	0.0	59.3
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	0.0	0.0	0.0	0.0

[a] NS = no sample

Table 7. Percent occurrence and weight of food items in digestive tracts of medium northern squawfish (100-249 mm) by sample period, John Day tailrace, The Dalles Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurence 1982	Percent occurence 1983	Percent weight 1982	Percent weight 1983
Apr 14 - Apr 20	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		77.8		85.3
(1983 - 9, 1)	Insecta	NS[a]	77.8	NS	14.5
	Osteichthyes		0.0		0.0
	Salmonidae		0.0		0.0
	Other food		33.3		0.2
May 4 - May 26	Mollusca				
(1982 - 0, 0)	Crustacea				
(1983 - 0, 0)	Insecta	NS	NS	NS	NS
	Osteichthyes				
	Salmonidae				
	Other food				
Jun 1 - Jun 22	Mollusca	16.7	6.7	3.9	37.8
(1982 - 6, 3)	Crustacea	0.0	33.3	0.0	1.4
(1983 - 15, 2)	Insecta	0.0	60.0	0.0	13.1
	Osteichthyes	0.0	0.0	0.0	0.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	50.0	40.0	96.1	47.5
Jul 5 - Jul 21	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		100.0		38.2
(1983 - 8, 0)	Insecta	NS	87.5	NS	60.9
	Osteichthyes		0.0		0.0
	Salmonidae		0.0		0.0
	Other food		12.5		0.9
Aug 2 - Aug 4	Mollusca	0.0		0.0	
(1982 - 4, 1)	crustacea	57.1		2.3	
(1983 - 0, 0)	Insecta	57.1	NS	37.7	NS
	Osteichthyes	0.0		0.0	
	Salmonidae	0.0		0.0	
	Other food	0.0		0.0	
Aug 31 - Sep 23	Mollusca	0.0	0.0	0.0	0.0
(1982 - 13, 1)	Crustacea	46.2	43.5	46.2	53.7
(1983 - 23, 7)	Insecta	76.9	17.4	40.6	0.1
	Osteichthyes	15.4	21.7	9.5	45.4
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	15.4	21.7	9.5	0.5

[a] NS = no sample

more than 24%. Insects were most important by weight at Irrigon except in June, 1983 when northern squawfish fed heavily on salmonids (61.2% by weight). Other food (primarily detritus) declined in importance at Irrigon between 1982 and 1983. At John Day tailrace, the most common food in the diet changed during each period sampled in 1983. In instances where comparable data from John Day tailrace in 1982 and 1983 were available, diets were generally similar. Fish were only important by weight in late August-September of 1983 (45.8%) at John Day tailrace. At John Day forebay, sample sizes were too small to make meaningful comparisons.

Large northern squawfish primarily ate fish, hut crustaceans and insects also contributed to the diet in 1982 and 1983 (Tables 8-11). Fish was the predominant food item by weight in all samples from McNary tailrace and John Day forebay in 1993. Salmonids were the primary fish group consumed by weight in 1983 at McNary tailrace in May (80.4%) and June (32.1%) and at John Day forebay in May (89.7%) and June-July 152.9%). Fish (primarily non-salmonids) accounted for the largest proportion of the diet by weight at Irrigon in all 1983 samples except May (14.6%) when crustaceans were dominant (81.0%). At John Day tailrace in 1983, fish were important by weight iron June to September, but salmonids were important only in July(40.8%). In general, the contribution of fish and particularly salmonids to the diet increased considerably from 1982 at McNary tailrace, John Day forebay, and Irrigon. However, fewer crustaceans were taken in 1983 than in 1982, particularly at McNary tailrace, Irriqon, and John Day tailrace.

Table 8. Percent occurrence and weight of food items in digestive tracts of large northern squawfish (> 250 mm) by sample period, McNary tailrace, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 4 - Apr 21					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 6, 3)	Crustacea	16.7	17.9	<0.1	2.1
(1983 - 31, 12)	Insecta	31.3	22.6	7.2	0.8
	Osteichthyes	16.7	45.2	[illegible]	96.6
	Salmonidae	0.0	12.9	0.0	33.8
	Other food	0.0	6.5	0.0	0.6
May 5 - May 20					
	Mollusca	0.0	4.9	0.0	0.4
(1982 - 7, 2)	Crustacea	57.1	42.3	94.6	7.0
(1983 - 123, 18)	Insecta	28.6	39.8	0.3	0.3
	Osteichthyes	14.3	56.9	5.1	92.2
	Salmonidae	0.0	46.3	0.0	80.4
	Other food	0.0	5.7	0.0	0.0
Jun 4 - Jun 22					
	Mollusca	0.0	11.9	0.0	13.6
(1982 - 5, 3)	Crustacea	40.0	51.7	99.4	43.0
(1983 - 118, 38)	Insecta	20.0	31.4	0.6	1.4
	Osteichthyes	0.0	23.7	0.0	42.1
	Salmonidae	0.0	16.1	0.0	72.1
	Other food	0.0	5.1	0.0	0.1
Aug 1 - Aug 25					
	Mollusca	6.9	11.1	12.2	8.6
(1982 - 87, 49)	Crustacea	23.0	36.3	7.4	21.1
(1983 - 135, 48)	Insecta	23.0	23.7	0.9	2.0
	Osteichthyes	19.5	28.9	79.5	65.2
	Salmonidae	6.9	9.9	28.3	24.6
	Other food	0.0	8.9	0.0	3.1

Table 9. Percent occurrence and weight of food items in digestive tracts of large northern squawfish (≥250 mm) by sample period, Irrigon, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 7982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 5 - Apr 22					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 12, 0)	Crustacea	58.3	16.7	36.5	2.4
(1983 - 6, 1)	Insecta	33.3	16.7	0.2	0.0
	Osteichthyes	58.3	50.0	53.3	93.R
	Salmonidae	33.3	0.0	21.7	0.0
	Other food	0.0	50.0	0.0	3.8
May 6 - May 24					
	Mollusca	11.1	33.3	1.1	4.0
(1982 - 9, 3)	Crustacea	44.4	50.0	14.7	81.0
(1983 - 72, 3)	Insecta	33.3	9.3	I.8	0.4
	Osteichthyes	22.2	76.7	5.9	74.6
	Salmonidae	11.1	0.0	0.0	0.0
	Other food	11.1	0.0	16.5	0.0
Jun 11 - Ju" 17					
	Mollusca	0.0	73.3	0.0	2.4
(1982 - 6, 3)	Crustacea	50.0	40.0	99.9	49.3
(1983 - 15, 9)	Insecta	16.7	20.0	0.7	0.4
	Osteichthyes	0.0	26.7	0.0	47.9
	Salmonidae	0.0	6.7	0.0	70.0
	Other food	0.0	0.0	0.0	0.0
Aug 3 - Aug 25					
	Mollusca	0.0	0.0	0.0	0.0
(7982 - 4, 2)	Crustacea	25.0	0.0	54.6	0.0
(1983 - 7, 3)	Insecta	25.0	42.9	45.5	47.5
	Osteichthyes	0.0	14.3	0.0	36.2
	Salmonidae	0.0	0.0	0.0	0.0
	other food	0.0	14.3	0.0	76.4

Table 10. Percent occurrence and weight of food items in digestive tracts Of large northern squawfish (≥250 mm) by sample period, John Day forebay, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 19 - May 11	Mollusca				
	Crustacea	0.0	0.0	0.0	0.0
(1982 - 19, 6)	Insecta	26.3	34.5	23.7	11.0
(1993 - '19, 35)		36.8	42.9	2.3	7.7
	Osteichthyes	42.1	20.2	74.1	79.0
	Salmonidae	31.6	16.0	49 .0	71.4
	Other food	0 .0	5.4	0.0	2.3
May 23 - Jun 8					
	Mollusca	0.0	0.8	0.0	<0.1
(1982 - 28, 11)	Crustacea	50.0	32.6	13.1	8.4
(1983 - 129, 42)	Insecta	21.4	17.8	0.2	0.6
	Osteichthyes	21.4	41.1	86.8	91 .0
	Salmonidae	14.3	36.4	71.6	89.7
	Other food	0 .0	1.6	0 .0	<0.1
Jun 21 - Jul 1					
	Mollusca	0.0	0.0	0.0	0 .0
(1982 - 8, 3)	Crustacea	37.5	25.9	82.0	36.9
(1983 - 54, 26)	Insecta	12.5	29.6	2.9	7.7
	osteichthyes	50.0	9.3	15.1	55.4
	Salmonidae	0.0	7.4	0 .0	52.9
	Other food	0 .0	0 .0	0 .0	0.0
Auq 17 - Sep 2					
	Mollusca	0.0	1.3	0.0	<0.1
(1982 - 52, 13)	Crustacea	13.5	25.3	18 .0	16.3
(1983 - 79, 20)	Insecta	69.2	57.0	51.3	23.6
	Ostaichthyes	3.9	19.0	30.6	57.0
	Salmonidae	1.9	3.8	12.1	19.1
	Other food	7.7	3.8	<0.1	3.2

Table 11. Percent occurrence and weight of food items in digestive tracts of large northern squawfish (>250 mm) by sample period, John Day tailrace, The Dalles Reservoir, 1982 and 1983. Sample sizes and numbers of empty digestive tracts are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 14 - Apr 20	Mollusca		20.0		6.5
(1982 - 0, 0)	Crustacea		65.7		72.6
(1983 - 35, 7)	Insecta	NS[a]	31.4	NS	15.4
	Osteichthyes		5.7		5.6
	Salmonidae		0.0		0.0
	Other food		2.9		<0.1
May 4 - May 26	Mollusca	20.0		1.6	
(1982 - 5, 0)	Crustacea	80.0		69.5	
(1983 - 0, 0)	Insecta	40.0	NS	2.7	NS
	Osteichthyes	40.0		13.6	
	Salmonidae	20.0		13.6	
	Other food	20.0		12.6	
Jun 1 - Jun 22	Mollusca	0.0	13.3	0.0	33.9
(1982 - 31, 24)	Crustacea	16.1	43.1	19.3	17.4
(1983 - 188, 81)	Insecta	3.2	5.3	0.1	<0.1
	Osteichthyes	6.5	9.0	80.7	48.4
	Salmonidae	0.0	2.7	0.0	15.1
	Other food	0.0	2.7	0.0	0.3
Jul 5 - Jul 21	Mollusca		6.4		5.2
(1982 - 0, 0)	Crustacea		38.2		49.2
(1983 - 249, 124)	Insecta	NS	9.6	NS	2.9
	Osteichthyes		9.2		42.6
	Salmonidae		7.6		40.5
	Other food		1.6		0.1
Aug 2 - Aug 4	Mollusca	11.6		36.0	
(1982 - 43, 18)	Crustacea	53.5		59.5	
(1983 - 0, 0)	Insecta	18.6	NS	0.9	NS
	Osteichthyes	9.3		3.6	
	Salmonidae	4.7		0.7	
	Other food	2.3		<0.1	
Aug 31 - Sep 23	Mollusca	1.9	1.5	0.2	4.3
(1982 - 52, 10)	Crustacea	1.9	9.5	0.3	5.9
(1983 - 137, 59)	Insecta	3.9	8.8	0.5	0.7
	Osteichthyes	76.9	43.1	99.0	57.3
	Salmonidae	9.6	5.1	17.3	29.6
	Other food	1.9	5.1	<0.1	1.8

[a] NS = no sample

Food Habits of Walleyes

Nearly one-half of the 492 walleye stomachs examined in 1983 were empty. Walleyes sampled ranged in length from 145 to 816 mm ($\overline{X}$ = 492 mm).

Fish accounted for more than 99% of the weight consumed by walleyes in 1983, as compared to more than 98% in 1982 (Table 12). Similar fish taxa including suckers (Catostomus spp.), sand roller (Percopsis transmontana), sculpins (Cottus spp.), and chiselmouth (Acrocheilus alutaceus) were taken in both years. Percent weight of salmonids in the walleye diet was 8.8% in 1982 and 6.0% in 1983. The smallest walleye found to ingest a fish was 141 mm in 1982 and 145 mm in 1983. The smallest walleye to consume a salmonid was 291 mm in 1983 as compared to 141 mm in 1982.

The percent by weight of fish in the diet of walleyes collected in 1982 and 1983 was greater than 90% in all 50 mm length groups except 150-200 mm (Fig. 2). Salmonids generally accounted for a higher percentage of the diet (>10% by weight) among walleyes less than 350 mm in length. Since fish accounted for greater than 50% weight of food in all length intervals, the data were combined for analysis by date and station.

Fish accounted for greater than 92% by weight of all food eaten by walleyes from McNary tailrace during all sampling periods in 1982 and 1983 (Table 13). Salmonids occurred in the diet during all sampling periods of 1983, but accounted for greater than 5% by weight only in April (8.7%) and August (22.4%). In 1982, salmonids were eaten only in

Table 12. Percent occurrence and weight of food items in stomachs of walleyes ranging in length from 141 to 695 mm in 1982 and 145 to 816 mm in 1983, John Day Reservoir and tailrace, April 4 to September 23, 1982 and 1983. Sample sizes and numbers of empty stomachs were 219 and 40, respectively, in 1982 and 492 and 244, respectively, in 1983.

Food item	Percent occurrence		Percent weight	
	1982	1983	1982	1983
MOLLUSCA				
Pelecypoda				
Corbicula manilensis	0.0	0.2	0.0	<0.1
CRUSTACEA	25.6	4.5	0.7	0.1
Cladocera	5.0	0.0	0.1	0.0
Copepoda	2.3	0.0	<0.1	0.0
Mysidacea	13.2	1.4	0.6	<0.1
Amphipoda	7.8	3.2	<0.1	<0.1
Anisogammarus spp.	1.8	0.8	<0.1	<0.1
Corophium spp.	6.4	3.0	<0.1	<0.1
Decapoda				
Pacifastacus leniusculus	0.5	0.2	<0.1	<0.1
INSECTA	25.1	5.9	0.6	0.1
Ephemeroptera	12.8	3.0	0.6	<0.1
Odonata	0.0	0.2	0.0	<0.1
Orthoptera	0.5	0.0	<0.1	0.0
Hemiptera	0.5	0.0	<0.1	0.0
Homoptera	0.5	0.0	<0.1	0.0
Coleoptera	0.0	0.2	0.0	<0.1
Trichoptera	0.0	0.4	0.0	<0.1
Diptera	13.2	2.2	<0.1	<0.1
Hymenoptera	0.5	0.0	<0.1	0.0
Unidentified Insecta	0.0	0.2	0.0	<0.1
OSTEICHTHYES	66.2	46.8	98.7	99.8
Clupeidae				
Alosa sapidissima	0.0	0.8	0.0	1.2
Salmonidae	16.0	7.5	8.8	6.0
Oncorhynchus tshawytscha	16.0	0.2	8.8	0.8
Prosopium williamsoni	0.0	0.2	0.0	1.2
Unidentified Salmonidae	0.0	7.3	0.0	4.0
Cyprinidae	19.6	11.4	38.1	17.0
Acrocheilus alutaceus	11.0	5.1	19.3	9.2
Mylocheilus caurinus	2.7	4.3	9.2	5.0
Ptychocheilus oregonensis	6.8	3.0	9.5	2.8
Richardsonius balteatus	0.5	0.0	<0.1	0.0
Catostomidae				
Catostomus spp.	10.5	14.0	30.2	35.9
Ictaluridae				
Ictalurus spp.	0.0	0.2	0.0	0.1
Percopsidae				
Percopsis transmontana	1.4	10.6	1.7	18.2
Cottidae				
Cottus spp.	14.6	12.8	14.6	17.9
Unidentified non-Salmonidae	24.7	15.0	5.2	3.5
OTHER FOOD	6.8	1.0	<0.1	<0.1

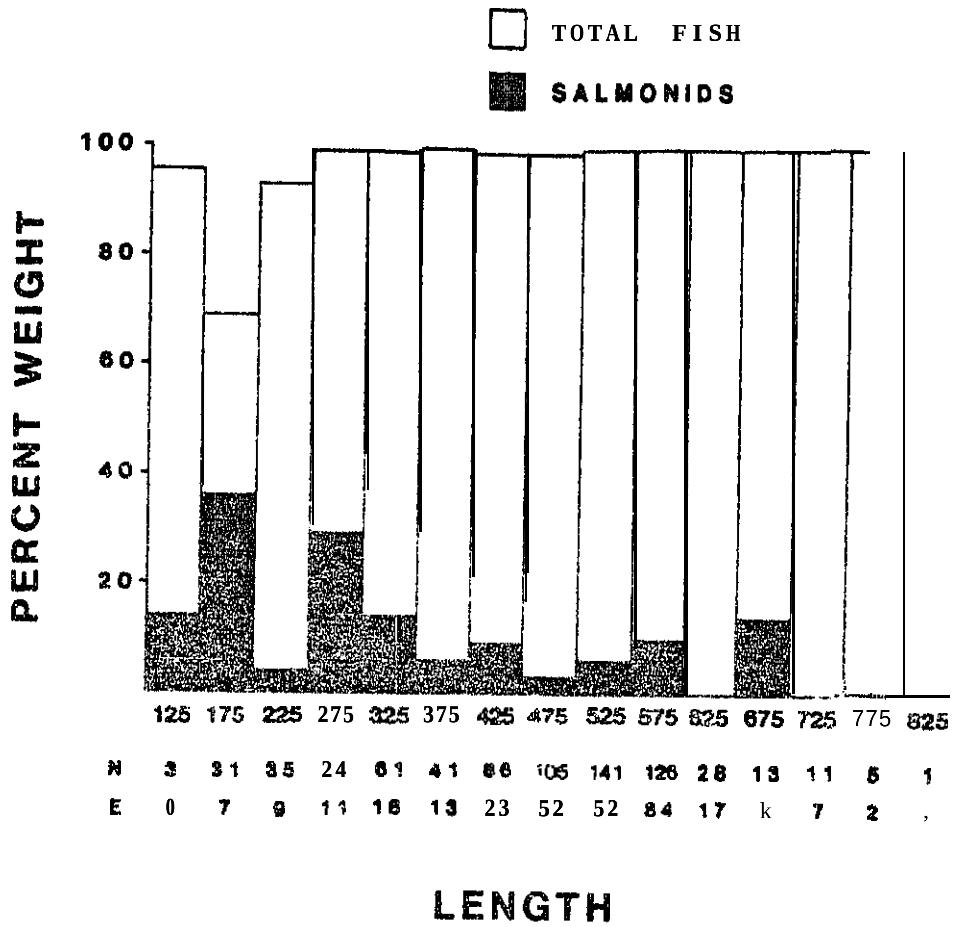

Figure 2. Percent weight of total fish and salmonids versus walleye length, John Day Reservoir and tailrace, 1982 and 1983. Lengths are midpoints of 50 mm intervals. N = number of stomachs analyzed; E = number of empty stomachs.

Table 13. Percent occurrence and weight of food items in stomachs of walleyes by sample period, McNary tailrace, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 4 - Apr 21					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 2, 0)	Crustacea	0.0	0.0	0.0	0.0
(1983 - 41, 24)	Insecta	0.0	2.4	0.0	<0.1
	Osteichthyes	100.0	39.0	100.0	>99.9
	Salmonidae	0.0	2.4	0.0	8.7
	Other food	0.0	0.0	0.0	0.0
May 5 - May 20					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 22, 5)	Crustacea	22.7	1.4	0.3	<0.1
(1983 - 71. 19)	Insecta	31.8	7.0	0.9	<0.1
	Osteichthyes	59.1	70.4	98.8	99.9
	Salmonidae	4.6	7.0	1.4	3.0
	Other food	0.0	1.4	0.0	<0.1
Jun 4 - Jun 22					
	Mollusca	0.0	1.5	0.0	<0.1
(1982 - 16, 5)	Crustacea	18.8	0.0	<0.1	0.0
(1983 - 67, 25)	Insecta	12.5	10.4	0.4	0.2
	Osteichthyes	62.5	59.7	99.5	99.8
	Salmonidae	0.0	4.5	0.0	0.7
	Other food	0.0	1.5	0.0	<0.1
Aug 1 - Aug 25					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 3, 0)	Crustacea	0.0	8.8	0.0	<0.1
(1983 - 34, 9)	Insecta	66.7	5.9	7.4	<0.1
	Osteichthyes	100.0	64.7	92.4	99.9
	Salmonidae	0.0	14.7	0.0	22.4
	Other food	33.3	5.9	0.2	<0.1

May. accounting for 1.4% by weight. Insects accounted for 7.4% by weight in August 1982, whereas in all other samples from 1982 and 1983, insect weight was less than 1.0%.

At Irrigon, fish contributed more than 98% by weight to the diet of walleyes during May, June, and August sampling periods of 1982 and 1983 (Table 14). Salmonids accounted for 15.8% and 13.2% by weight in May 1982 and 1983, respectively, and for 100% and 6.2% by weight in June 1982 and 1983, respectively.

No walleyes were collected during 1983 from John Day forebay. only three walleyes were collected there in 1982; all had empty stomachs.

Fish accounted for greater than 98% by weight of stomach contents of walleyes from John Day tailrace in all 1982 and 1983 sampling periods except an August, 1952 sample (Table 15). Salmonids accounted for more than 36% of the food weight in April 1983 and about 13.6% in May 1982. In both cases, there was no sample for comparison between years. Insects were a major contributor to the diet (31.8% by weight) only in an August, 1982 sample.

Table 14. Percent occurrence and weight of food items in stomachs of walleyes by sample period, Irrigon, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence		Percent weight	
		1982	1983	1982	1983
Apr 5 - Apr 22					
	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		0.0		0.0
(1983 - 3, 3)	Insecta	NS[a]	0.0	NS	0.0
	Osteichthyes		0.0		0.0
	Salmonidae		0.0		0.0
	Other food		0.0		0.0
May 6 - May 24					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 17, 0)	Crustacea	70.6	2.9	1.2	0.3
(1983 - 68, 52)	Insecta	47.1	1.5	0.2	0.2
	Osteichthyes	70.6	23.5	98.4	99.5
	Salmonidae	23.5	5.9	15.8	13.2
	Other food	29.4	0.0	<0.1	0.0
Jun 11 - Jun 17					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 3, 1)	Crustacea	0.0	7.8	0.0	<0.1
(1983 - 64. 39)	Insecta	0.0	7.8	0.0	0.1
	Osteichthyes	66.7	39.1	100.0	99.8
	Salmonidae	66.7	21.9	100.0	6.2
	Other food	0.0	1.6	0.0	<0.1
Aug 3 - Aug 25					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 2, 0)	Crustacea	50.0	0.0	<0.1	0.0
(1983 - 7, 5)	Insecta	50.0	14.3	<0.1	<0.1
	Osteichthyes	100.0	28.6	>99.9	>99.9
	salmonidae	0.0	0.0	0.0	0.0
	Other food	0.0	0.0	0.0	0.0

[a] NS = no sample

Table 15. Percent occurrence and weight of food items in stomachs of walleyes by sample period, John Day tailrace, The Dalles Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 14 - Apr 20	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		15.2		0.9
(1983 - 33, 19)	Insecta	NS[a]	0.0	NS	0.0
	Osteichthyes		36.4		99.1
	Salmonidae		6.1		34.6
	Other food		0.0		0.0
May 4 - May 26	Mollusca	0.0		0.0	
(1982 - 49, 7)	Crustacea	28.6		0.8	
(1983 - 0, 0)	Insecta	14.3	NS	0.2	NS
	Osteichthyes	71.4		98.9	
	Salmonidae	22.4		13.6	
	Other food	6.1		<0.1	
Jun 1 - Jun 22	Mollusca	0.0	0.0	0.0	0.0
(1982 - 63, 13)	Crustacea	22.2	7.2	0.7	0.8
(1983 - 69, 34)	Insecta	27.0	7.2	<0.1	<0.1
	Osteichthyes	63.4	42.0	99.1	99.1
	Salmonidae	23.8	2.9	5.9	1.3
	Other food	6.4	0.0	0.1	0.0
Jul 5 - Jul 21	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		4.6		<0.1
(1983 - 22, 9)	Insecta	NS	9.1	NS	0.3
	Osteichthyes		50.0		99.7
	Salmonidae		0.0		0.0
	Other food		0.0		0.0
Aug 2 - Aug 4	Mollusca	0.0		0.0	
(1982 - 8, 0)	Crustacea	25.0		0.5	
(1983 - 0, 0)	Insecta	62.5	NS	31.8	NS
	Osteichthyes	75.0		67.7	
	Salmonidae	0.0		0.0	
	Other food	0.0		0.0	
Aug 31 - Sep 23	Mollusca	0.0	0.0	0.0	0.0
(1982 - 1, 0)	Crustacea	0.0	0.0	0.0	0.0
(1983 - 13, 6)	Insecta	0.0	0.0	0.0	0.0
	Osteichthyes	100.0	53.8	100.0	100.0
	Salmonidae	0.0	7.7	0.0	2.5
	Other food	0.0	0.0	0.0	0.0

[a] NS = no sample

Food Habits of Smallmouth Bass

Stomach contents of 1,064 smallmouth bass, collected from April to September, 1983, were analyzed. Lengths ranged from 50 to 583 mm ($\bar{x}$ = 227 mm). Twenty-four percent (252) of the stomachs were empty.

Fish and crayfish (Pacifastacus leniusculus) accounted for more than 97% of the weight of food items consumed by smallmouth bass in 1982 and 1983 (Table 16). Fish, primarily non-salmonid, was also the predominant food item among all length groups of smallmouth bass examined (Fig. 3). The smallest smallmouth bass which consumed a fish was 44 mm in 1982 and 69 mm in 1983. The smallest smallmouth bass that consumed a salmonid was 189 mm in 1982 and 78 mm in 1983. Since fish comprised greater than 50% of the food consumed hy weight in all length intervals, the data were combined for analysis hy date and station.

Fish was the dominant Food item hy weight at McNary tailrace and Irrigon throughout all samplinq periods in 1982 and 1983 (Tables 17-19). Sculpins and suckers were the primary fish eaten at McNary tailrace in 1982 and 1983 and at Irrigon in 1983. Sculpinsalone were important at Irrgon in 1982 except in Augiust when a variety of fish were consumed.

Crustaceans and fish contributed more than 94% of the weight consumed by smallmouth bass from John Day forebay and tailrace in 1982 and 1983 (Tables 19 and 20). Crustaceans were the primary food eaten at John Day forebay in 1983 during the April-May (74.4%) and June-July samples (75.1%), while fish were most important in the other sample periods. In 1982 the opposite was true, with fish important in April-May (86.1%) and Juno-July (70.3%) samples and crustaceans

Table 16. Percent occurrence and weight of food items in stomachs of smallmouth bass ranging in length from 44 to 470 mm in 1982 and 50 to 583 mm in 1983, John Day Reservoir and tailrace, April 4 to September 23, 1982 and 1983. Sample sizes and numbers of empty stomachs were 847 and 116, respectively, in 1982 and 1,064 and 252, respectively, in 1983.

Food item	Percent occurrence		Percent weight	
	1982	1983	1982	1983
MOLLUSCA	0.7	0.3	<0.1	<0.1
Pelecypoda				
Corbicula manilensis	0.7	0.3	<0.1	<0.1
CRUSTACEA	50.4	38.9	27.5	18.9
Cladocera	7.1	3.3	0.1	<0.1
Copepoda	2.1	2.2	<0.1	<0.1
Mysidacea	2.8	2.4	0.6	0.3
Isopoda	0.5	0.3	<0.1	<0.1
Amphipoda	27.0	18.4	0.4	0.6
Anisogammarus spp.	15.9	9.0	0.2	0.3
Corophium spp.	17.2	10.3	0.2	0.3
Unidentified Amphipoda	0.0	2.1	0.0	<0.1
Decapoda				
Pacifastacus leniusculus	25.4	20.0	26.4	18.1
INSECTA	43.2	21.2	1.3	0.5
Collembolla	0.0	0.1	0.0	<0.1
Ephemeroptera	10.4	5.8	0.3	0.1
Odonata	1.3	0.5	0.1	<0.1
Orthoptera	0.2	0.0	<0.1	0.0
Plecoptera	0.0	0.1	0.0	<0.1
Thysanoptera	0.1	0.0	<0.1	0.0
Hemiptera	1.8	0.8	<0.1	<0.1
Homoptera	0.8	1.1	<0.1	<0.1
Coleoptera	1.8	0.8	0.3	<0.1
Trichoptera	1.2	1.0	<0.1	<0.1
Lepidoptera	0.0	0.1	0.0	<0.1
Diptera	27.0	11.5	0.1	0.2
Hymenoptera	7.7	2.9	0.4	0.2
Unidentified Insecta	7.2	2.6	0.1	<0.1
OSTEICHTHYES	43.0	42.2	70.8	80.3
Clupeidae				
Alosa sapidissima	1.4	0.0	0.1	0.0
Salmonidae	0.6	2.2	0.4	1.3
Oncorhynchus tshawytscha	0.6	0.2	0.4	<0.1
Unidentified Salmonidae	0.0	2.0	0.0	1.3
Cyprinidae	10.4	7.1	16.6	12.3
Acrocheilus alutaceus	2.2	0.7	9.3	2.7
Cyprinus carpio	0.1	0.0	0.2	0.0
Mylocheilus caurinus	2.7	1.8	2.2	3.4
Ptychocheilus oregonensis	6.1	5.0	4.9	6.1
Catostomidae				
Catostomus spp.	6.5	10.5	13.4	28.1
Ictaluridae				
Ictalurus spp.	0.0	0.1	0.0	0.1
Percopsidae				
Percopsis transmontana	0.0	1.6	0.0	1.4
Centrarchidae	0.5	0.6	0.5	1.0
Cottidae				
Cottus spp.	14.6	18.5	35.5	32.9
Unidentified non-Salmonidae	15.6	13.1	4.5	3.1
Unidentified Osteichthyes	0.0	0.9	0.0	<0.1
OTHER FOOD	12.6	7.3	0.3	0.3

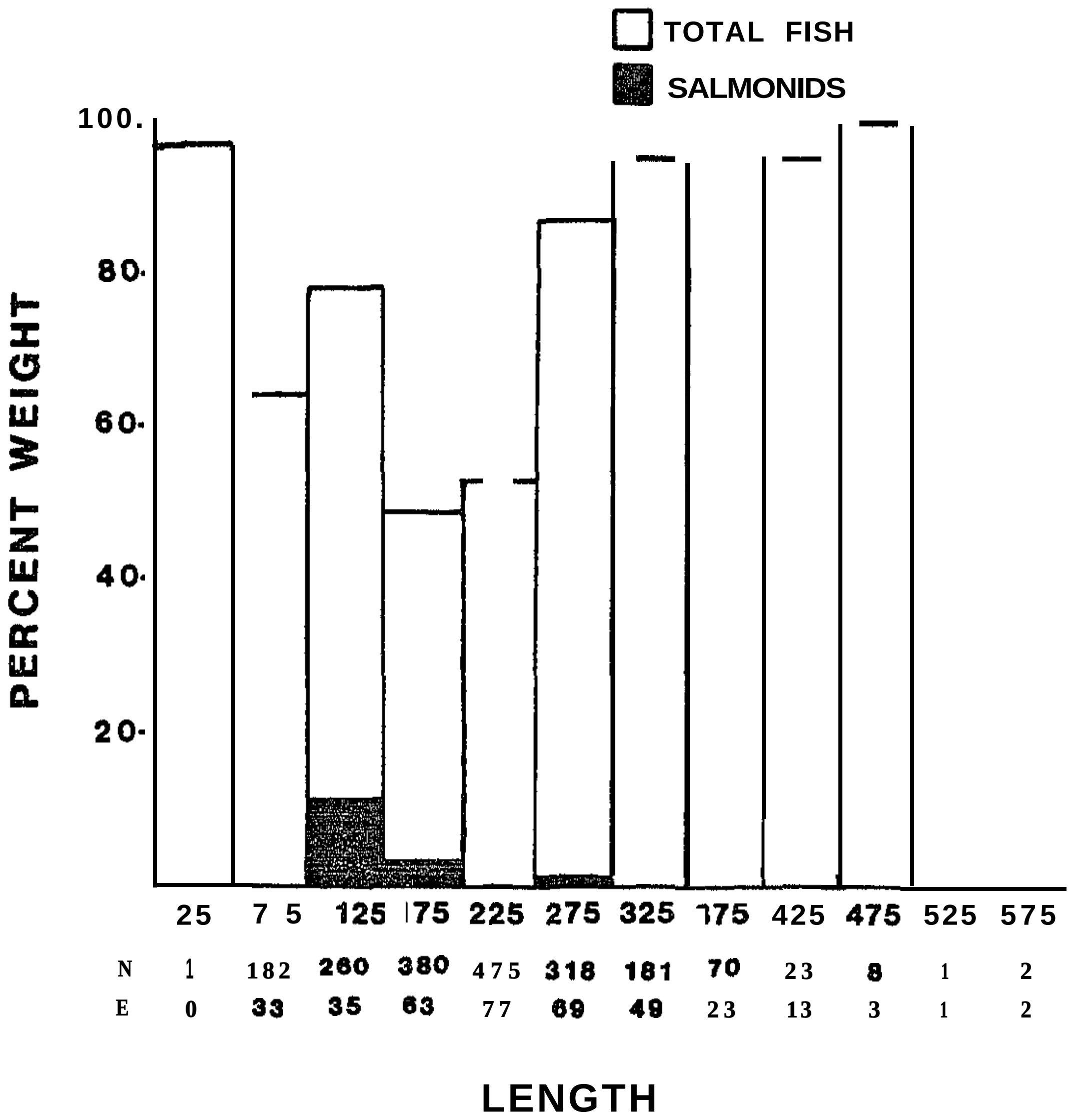

Figure 3. Percent weight of total fish and salmonids versus smallmouth bass length, John Day Reservoir and tailrace, 1982 and 1983. Lengths are midpoints of 50 mm intervals. N = number of stomachs analyzed; E = number of empty stomachs.

Table 17. Percent occurrence and weight of food items in stomachs of smallmouth bass by sample period, McNary tailrace, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 4 - Apr 21					
	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		0.0		0.0
(1983 - 6, 5)	Insecta	NS[a]	0.0	NS	0.0
	Osteichthyes		16.7		100.0
	Salmonidae		0.0		0.0
	Other food		0.0		0.0
May 5 - May 20					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 11, 0)	Crustacea	36.4	13.3	2.0	2.9
(1983 - 15, 7)	Insecta	45.5	20.0	0.1	1.0
	osteichthyes	72.1	46.7	97.9	96.1
	Salmonidae	0.0	0.0	0.0	0.0
	other food	9.1	0.0	<0.1	0.0
Jun 4 - Jun 22					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 15, 1)	Crustacea	20.0	0.0	0.8	0.0
(1983 - 15, 7)	Insecta	66.7	0.0	1.2	0.0
	osteichthyes	66.7	53.3	97.4	100.0
	Salmonidae	0.0	6.7	0.0	0.8
	other food	20.0	0.0	0.6	0.0
Aug 1 - Aug 25					
	Mollusca	0.0	3.9	0.0	<0.1
(1982 - 8, 0)	Crustacea	37.5	23.1	5.3	1.2
(1983 - 26, 3)	Insecta	62.5	19.2	0.2	<0.1
	Osteichthyes	87.5	84.6	94.5	98.7
	Salmonidae	0.0	7.7	0.0	7.8
	other food	0.0	3.9	0.0	<0.1

[a] NS = no sample

Table 18. Percent occurrence and weight of food items in stomachs of smallmouth bass by sample period, Irrigon, John Day Reservoir, 1982 and 1993. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 5 - Apr 22					
	Mollusca	0.0	2.6	0.0	0.1
(1982 - 5, 11	crustacea	40.0	20.5	6.9	3.2
(1983 - 39, 16)	Insecta	20.0	12.8	1 .0	0.2
	Osteichthyes	60.0	43.6	92.1	96.5
	Salmonidae	0.0	0.0	0.0	0 .0
	other food	0 .0	5.1	0.0	0.1
May 6 - May 24					
	Mollusca	4.8	0.7	0.1	0.1
(1942 - 42, 7)	Crustacea	23.8	14.2	0.1	2.6
(1983 - 148, 53)	Insecta	50.0	10.1	0.3	0.2
	Qsteichthyes	54.8	52.7	99.5	97.2
	Salmonidae	0.0	4.1	0.0	1.0
	other food	19.1	3.4	0.1	<0.1
Jun 11 - Jun 17					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 72, 16)	Crustacea	25.0	18.9	1.3	3.3
(1983 - 133, 26)	Insectsa	44.4	36.8	3.6	0.5
	Osteichthyes	54.2	66.2	94.6	95.1
	Salmonidae	4.2	4.5	3.7	1.3
	Other food	8.3	10.5	0.5	0.1
Aug 3 - Aug 25					
	Mollusca	1.8	0.0	<0.1	0.0
(1982 - 55, 101	crustacea	27.3	9.0	0.8	0.1
(1983 - 144, 35)	Insecta	63.6	25.0	0.6	0.5
	Osteichthyes	70.9	56.3	98.4	99.2
	Salmonidae	0.0	1.4	0.0	2.4
	Other food	14.6	13.9	0.2	0.3

Table 19. Percent occurence and weight of food items in stomachs of smallmouth bass by sample period, John Day forebay, John Day Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurence 1982	Percent occurence 1983	Percent weight 1982	Percent weight 1983
Apr 19 - May 11					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 16, 2)	Crustacea	43.8	58.0	12.7	74.4
(1983 - 81, 22)	Insecta	12.5	24.7	1.3	5.3
	Osteichthyes	50.0	14.8	86.1	20.2
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	0.0	2.5	0.0	0.1
May 23 - Jun 8					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 127, 17)	Crustacea	70.1	63.2	62.1	38.8
(1983 - 114, 18)	Insecta	34.7	25.4	0.8	0.4
	Osteichthyes	18.9	27.2	36.8	58.8
	Salmonidae	0.8	2.6	0.1	0.7
	Other food	13.4	7.0	0.4	2.0
Jun 21 - Jul 1					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 105, 18)	Crustacea	61.9	77.5	28.4	75.1
(1983 - 90, 11)	Insecta	41.9	13.3	1.2	0.1
	Osteichthyes	19.1	28.9	70.3	24.7
	Salmonidae	0.0	2.2	0.0	0.8
	Other food	17.1	7.8	0.1	0.1
Aug 17 - Sep 2					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 73, 3)	Crustacea	78.1	69.2	48.2	41.1
(1983 - 107, 11)	Insecta	57.5	21.5	2.4	0.8
	Osteichthyes	52.1	29.9	49.3	58.0
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	6.9	8.4	<0.1	0.1

Table 20. Percent occurrence and weight of food items in stomachs of smallmouth bass by sample period, John Day tailrace, The Dalles Reservoir, 1982 and 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence 1982	Percent occurrence 1983	Percent weight 1982	Percent weight 1983
Apr 14 - Apr 20					
	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		21.7		25.7
(1983 - 23, 15)	Insecta	NS[a]	4.4	NS	<0.1
	Osteichthyes		17.4		74.3
	Salmonidae		0.0		0.0
	Other food		0.0		0.0
May 4 - May 26					
	Mollusca	0.0		0.0	
(1982 - 2, 0)	Crustacea	0.0		0.0	
(1983 - 0, 0)	Insecta	50.0	NS	<0.1	NS
	Osteichthyes	50.0		100.0	
	Salmonidae	0.0		0.0	
	Other food	0.0		0.0	
Jun 1 - Jun 22					
	Mollusca	7.7	0.0	0.4	0.0
(1982 - 26, 2)	Crustacea	69.2	51.5	45.0	19.0
(1983 - 66, 17)	Insecta	42.3	21.2	1.0	0.1
	Osteichthyes	26.9	30.3	51.8	80.4
	Salmonidae	0.0	1.5	0.0	0.1
	Other food	23.1	9.1	1.8	0.6
Jul 5 - Jul 21					
	Mollusca		0.0		0.0
(1982 - 0, 0)	Crustacea		73.1		18.3
(1983 - 26, 4)	Insecta	NS	23.1	NS	0.3
	Osteichthyes		38.5		81.3
	Salmonidae		0.0		0.0
	Other food		3.9		0.1
Aug 2 - Aug 4					
	Mollusca	0.0		0.0	
(1982 - 14, 0)	Crustacea	78.6		37.2	
(1983 - 0, 0)	Insecta	57.1	NS	0.7	NS
	Osteichthyes	78.6		62.1	
	Salmonidae	0.0		0.0	
	Other food	0.0		0.0	
Aug 31 - Sep 23					
	Mollusca	0.0	0.0	0.0	0.0
(1982 - 33, 3)	Crustacea	66.7	36.4	59.9	21.5
(1983 - 11, 2)	Insecta	42.4	9.1	3.4	<0.1
	Osteichthyes	45.5	54.6	35.4	78.5
	Salmonidae	0.0	0.0	0.0	0.0
	Other food	12.1	9.1	1.3	0.1

[a] NS = no sample

important in the other two samples. Crustaceans were never the dominant food item at John Day tailrace in 1983, but they contributed about 20% by weight in each sample period. Generally, crustaceans contributed less by weight in 1983 than in 1982. Crayfish were the primary crustacean consumed by weight in both years, although mysids were also consumed at John Day tailrace in June 1982. Sculpins were the primary fish taxon consumed by weight at John Day tailrace in 1982 and 1983. Sculpins were also the most important fish consumed at John Day forebay in both years.

Food Habits of Channel Catfish

Stomach analyses were completed on 189 channel catfish ranging from 166 to 718 mm ($\bar{x}$ = 486 mm); empty stomachs made up 27.5% of the sample.

Diets of channel catfish varied substantially between 1982 and 1983 as a result of eliminating the John Day River transect and increasing Sampling effort at McNary tailrace,Irrigon, and John Day tailrace in 19133. Only 8 channel catfish were collected during similar sample periods in 1982 making comparisons between years inappropriate.

In general, the diet of channel catfish in 1983 was primarily composed of fish (73.9% by weight) and crustaceans (16.4% by weight) (Table 21). The most important fish families consumed by weight were salmonids (17.7%), sculpins (16.4%), and suckers (15.1%;). Crayfish accounted for over 98% of the crustacean weight, and 16.2% of the total weight of food.

Fish represented over 50% by weight of the diet in most 50 mm size intervals when adequate sample sizes were obtained (Fig. 4). Importance of salmonids to the diet increased with length among channel catfish between 350 and 600 mm.

Fish accounted for greater than 70% by weight of stomach contents during all sampling periods at McNary tailrace (Table 22). Percent by weiqht of salmonids was 59.5% in May and 58.8% in June.

At Irriqon, fish accounted for less by weight in succeedinq sampling periods, ranging from 93.1% in April to 37.2% in August (Table 23). In contrast, crustaceans accounted for an increasingly

Table 21. Percent occurrence and weight of food items in stomachs of channel catfish ranging from 166 to 718 mm in length, John Day Reservoir and tailrace, April 4 to September 23, 1983. Sample size and number of empty stomachs were 189 and 52, respectively.

Food item	Percent occurrence 1983	Percent weight 1983
MOLLUSCA	6.3	4.2
Pelecypoda		
Corbicula manilensis	5.8	4.2
Gastropoda	0.5	<0.1
CRUSTACEA	41.0	16.4
Mysidacea	3.2	<0.1
Isopoda	0.5	<0.1
Amphipoda	21.6	0.2
Anisogammarus spp.	3.7	<0.1
Corophium spp.	21.6	0.2
Decapoda		
Pacifastacus leniusculus	26.8	16.2
INSECTA	23.7	0.9
Ephemeroptera	7.9	0.1
Odonata	0.5	<0.1
Orthoptera	0.5	<0.1
Plecoptera	0.5	<0.1
Homoptera	0.5	<0.1
Coleoptera	1.6	<0.1
Trichoptera	3.2	<0.1
Lepidoptera	0.5	<0.1
Diptera	12.6	0.7
Hymenoptera	0.5	<0.1
Unidentified Insecta	1.6	0.1
OSTEICHTHYES	41.0	71.9
Salmonidae	9.5	17.7
Oncorhynchus tshawytscha	2.1	3.8
Salmo gairdneri	1.6	6.2
Unidentified Salmonidae	6.8	7.7
Cyprinidae	4.7	8.3
Acrocheilus alutaceus	1.0	1.8
Mylocheilus caurinus	0.5	0.2
Ptychocheilus oregonensis	0.5	1.6
Cyprinus carpio	2.6	1.8
Catostomidae		
Catostomus spp.	1.0	15.1
Percopsidae		
Percopsis transmontana	1.0	0.3
Centrarchidae	1.0	1.3
Cottidae		
Cottus spp.	11.0	16.4
Unidentified non-Salmonidae	16.3	10.6
Unidentified Osteichthyes	4.2	4.2
OTHER FOOD	22.1	4.5

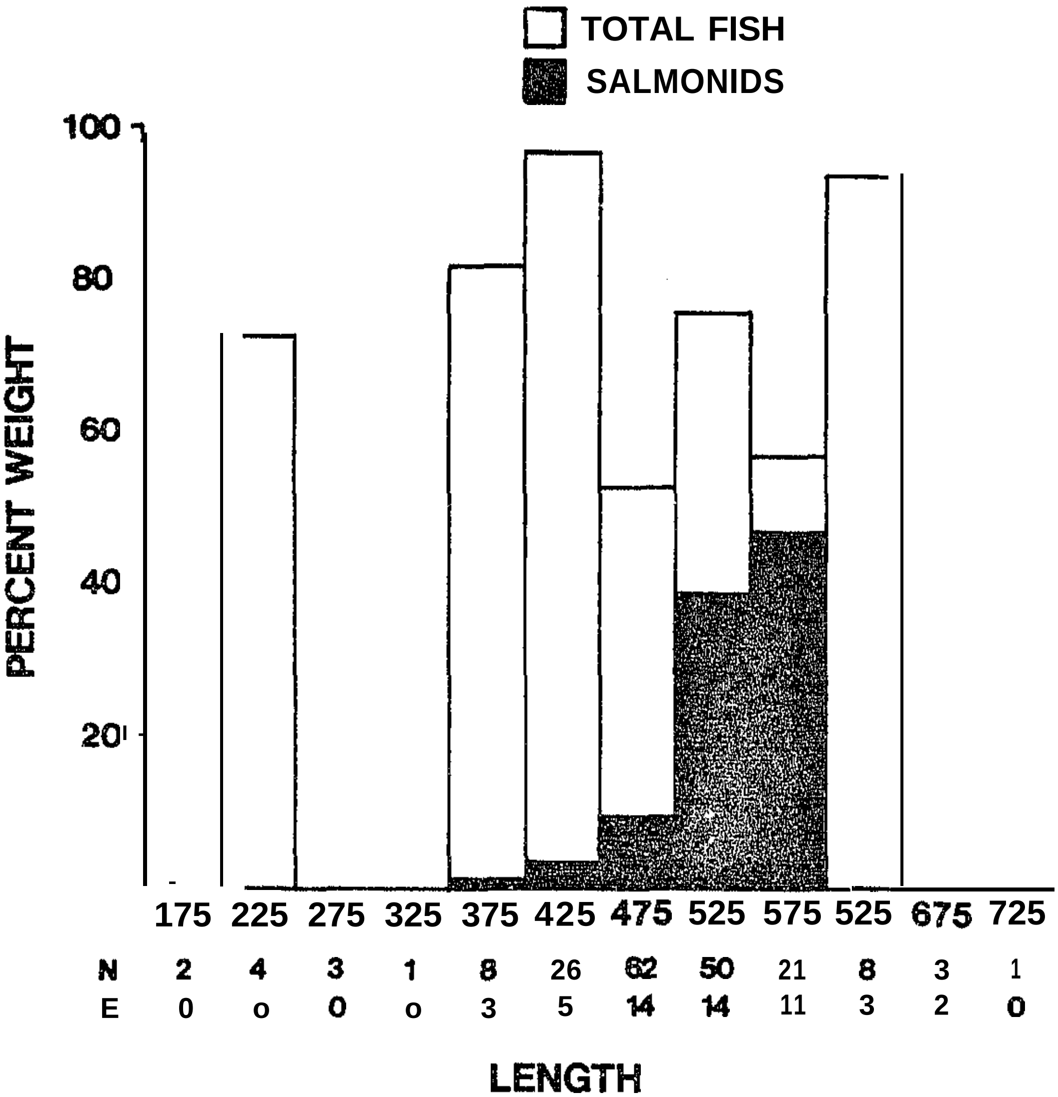

Figure 4. Percent weiqht of total fish and salmonids versus channel catfish length, John Day Reservoir and tailrace, 1983. Lengths are midpoints of 50 mm intervals. N = number of stomachs analyzed; E = number of empty stomachs.

Table 22. Parcent occurrence and weight of food items in stomachs of channel catfish by sample period, McNary tailrace, John Day Reservoir, 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence	Percent weight
Apr 4 - Apr 21			
	Mollusca	0.0	0.0
(9, 1)	Crustacea	44.4	2.3
	Insecta	55.6	3.3
	Osteichthyes	55.6	82.8
	Salmonidae	0.0	0.0
	Other food	33.3	11.7
May 5 - May 20			
	Mollusca	0.0	0.0
(38, 10)	Crustacea	36.8	2.0
	Insecta	18.4	3.2
	Osteichthyes	39.5	93.9
	Salmonidae	26.3	59.5
	Other food	15.8	0.9
Jun 4 - Jun 22			
	Mollusca	3.4	<0.1
(28, 13)	Crustacea	44.8	24.0
	Insecta	13.8	0.8
	Osteichthyes	24.1	73.1
	Salmonidae	13.8	58.8
	Other food	20.7	2.0
Aug 1 - Aug 25			
	Mollusca	33.3	<0.1
(3, 0)	Crustacea	0.0	0.0
	Insecta	66.7	1.5
	Osteichthyes	100.0	98.5
	Salmonidae	0.0	0.0
	Other food	0.0	0.0

Table 23. Percent occurrence and weight of food items in stomachs of channel catfish by sample period, Irrigon, John Day Reservoir, 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence	Percent weight
Apr 5 - Apr 22			
	Mollusca	0.0	0.0
(19, 5)	Crustacea	15.8	1.4
	Insecta	52.6	1.2
	Osteichthyes	57.9	93.1
	Salmonidae	0.0	0.0
	Other food	31.6	4.3
May 6 - May 24			
	Mollusca	17.6	0.2
(17, 5)	Crustacea	41.2	12.4
	Insecta	17.6	0.8
	Osteichthyes	35.3	65.2
	Salmonidae	5.9	42.5
	Other food	23.5	21.3
Jun 11 - Jun 17			
	Mollusca	24.0	15.4
(25, 11)	Crustacea	32.0	26.2
	Insecta	4.0	<0.1
	Osteichthyes	36.0	52.6
	Salmonidae	4.0	1.2
	Other food	16.0	5.8
Aug 3 - Aug 24			
	Mollusca	7.1	8.3
(14, 0)	Crustacea	85.7	54.4
	Insecta	21.4	0.1
	Osteichthyes	78.6	37.2
	Salmonidae	0.0	0.0
	Other food	7.1	<0.1

greater percent by weight with succeeding sampling periods, ranging from 1.4% in April to 54.4% in August. Salmonids were important by weight in May (42.5%). Mollusca were of some importance in June (15.4% by weight) and August (8.3% by weight).

Only one channel catfish was collected from John Day forebay in 1983. It's stomach contained two crayfish.

Fish accounted for the largest percent by weight in channel catfish from John Day tailrace during April, June, and July (Table 24). Salmonids were of some importance only in June (10.3%). Crustaceans, primarily crayfish, were of major importance in July (35.3% by weight) and accounted for 97.2% by weight during the August-September sample.

Table 24. Percent occurrence and weight of food items in stomachs channel catfish by sample period, John Day tailrace, The Dalles Reservoir, 1983. Sample sizes and numbers of empty stomachs are in parentheses.

Date	Food item	Percent occurrence	Percent weight
Apr 14 - Apr 20			
	Mollusca	0.0	0.0
(15, 4)	Crustacea	33.3	5.3
	Insecta	20.0	0.1
	Osteichthyes	20.0	87.1
	Salmonidae	0.0	0.0
	Other food	26.7	7.4
Jun 1 - Jun 22			
	Mollusca	0.0	0.0
(9, 1)	Crustacea	55.6	1.00
	Insecta	33.3	0.1
	Osteichthyes	55.6	98.2
	Salmonidae	22.2	10.3
	Other food	33.3	0.7
Jul 5 - Jul 21			
	Mollusca	0.0	0.0
(7, 2)	Crustacea	57.1	35.3
	Insecta	42.9	1.2
	Osteichthyes	14.3	55.0
	Salmonidae	0.0	0.0
	Other food	42.9	8.5
Aug 31 - Sep 23			
	Mollusca	0.0	0.0
(1, 0)	Crustacea	100.0	97.2
	Insecta	0.0	0.0
	nsteichthyes	100.0	2.8
	Salmonidae	0.0	0.0
	Other food	0.0	0.0

Apparent Abundance of Predators

Mean catch per transect (CPT) of northern squawfish, walleyes, and smallmouth bass during 1983 illustrated the same wide variability in apparent abundance as observed in 1982 (Tables 25-27). Northern squawfish were again most abundant in restricted zones at John Day and McNary tailraces with an overall CPT of 8.21 and 7.81, respectively. Overall CPT of northern squawfish out of tailrace restricted zones and in the restricted zone at John Day forebay was substantially lower, ranging between 0.13 and 2.25. Catch rates of walleyes during 1982 were similar to 1983 with highest catches at John Day tailrace and lowest at John Day forebay. Catches of smallmouth bass were similar during 1982 and 1983 except at John Day forebay. Overall CPT of smallmouth bass at this station dropped from 5.22 fish per transect in 1982 to 1.65 fish per transect in 1983.

Apparent abundance of predators varied among sample periods during 1983 and trends were not discernible except at stations where predators were most abundant. Mean catch of northern squawfish in tailrace restricted zones was less than 0.5 fish per transect during April and ranged between 7.0 and 13.39 fish per transect during other time periods. Similarly, catch of smallmouth bass at Irrigon and John Day forebay was lowest in April and highest during other time periods. Catch of walleyes at John Day tailrace was greater than 3.0 fish per transect during June and less than 1.0 fish per transect during other time periods.

Table 25. Mean catch per transect (CPT) of northern squawfish ($\geq$250 mm) collected with boat electroshocker by sample period at each station, John Day Reservoir and tailrace, 1982 and 1983.

	Out of restricted zone				Restricted zone			
	1982		1983		1982		1983	
	# of trans.	CPT	# of trans.	CPT	# of trans.	CPT	# of trans.	CPT
McNary tailrace								
Apr 4 - Apr 21	13	0.31	16	0.25	2	1.00	13	0.15
May 5 - May 20	16	0.38	15	0.87	1	0.00	12	10.00
Jun 4 - Jun 22	15	0.20	15	1.20	1	2.00	11	9.09
Aug 1 - Aug 25	14	0.43	16	0.50	9	9.44	14	12.00
Overall CPT		0.33		0.71		3.11		7.81
Irrigon								
Apr 5 - Apr 22	16	0.81	15	0.00				
May 6 - May 24	16	0.63	15	0.27				
Jun 11 - Jun 17	16	0.38	15	0.20			N/A	
Aug 3 - Aug 25	15	0.13	16	0.06				
Overall CPT		0.49		0.13				
John Day forebay								
Apr 19 - May 11	11	1.36	15	1.00	0		30	2.47
May 23 - Jun 8	72	2.17	15	1.33	0		25	3.64
Jun 21 - Jul 1	12	0.50	13	0.85	0		25	0.96
Aug 17 - Sep 2	8	1.38	16	0.81	6	6.17	23	1.91
Overall CPT		1.35		1.00		6.17		2.25
John Day tailrace								
Apr 14 - Apr 20	0		16	0.38	0		16	0.44
Jun 1 - Jun 22	17	0.41	15	2.87	0		10	12.00
Jul 5 - Jul 21	0		15	3.33	0		15	7.00
Aug 31 - Sep 23	0		14	1.64	6	8.83	18	13.39
Overall CPT		0.41		2.06		8.83		8.21

Table 26. Mean catch per transect (CPT) of walleyes collected with boat electroshocker by sample period at each station, John Day Reservoir and tailrace, 1982 and 1983.

	1982		1983	
	# of trans.	CPT	# of trans.	CPT
McNary tailrace				
Apr 4 - Apr 21	13	0.08	16	0.25
May 5 - May 20	16	0.44	15	0.33
Jun 4 - Jun 22	15	0.60	15	0.40
Aug 1 - Aug 25	14	0.14	16	0.19
Overall CPT		0.32		0.29
Irrigon				
Apr 5 - Apr 22	16	0.00	15	0.00
May 6 - May 24	16	1.06	15	0.07
Jun 11 - Jun 17	16	0.19	15	0.40
Aug 3 - Aug 25	15	0.07	16	0.13
Overall CPT		0.33		0.15
John Day forebay				
Apr 19 - May 11	11	0.00	15	0.00
May 23 - Jun 8	12	0.08	15	0.00
Jun 21 - Jul 1	12	0.00	13	0.00
Aug 17 - Sep 2	8	0.00	16	0.00
Overall CPT		0.02		0.00
John Day tailrace				
Apr 14 - Apr 20	0		16	0.50
Jun 1 - Jun 22	17	2.82	15	3.20
Jul 5 - Jul 21	0		15	0.33
Aug 31 - Sep 23	0		14	0.14
Overall CPT		2.82		1.04

Table 27. Mean catch per transect (CPT) of smallmouth bass collected with boat electroshocker hy sample period at each station, John Day Reservoir and tailrace, 1982 and 1983.

	1982		1983	
	# of trans.	CPT	# of trans.	CPT
McNary tailrace				
Apr 4 - Apr 21	13	0.00	16	0.19
May 5 - May 20	16	0.31	15	0.13
Jun 4 - Jun 22	15	0.60	15	0.53
Aug 1 - Aug 25	14	0.07	16	0.06
Overall CPT		0.25		0.23
Irrigon				
Apr 5 - Apr 22	16	0.31	15	0.60
May 6 - May 24	16	2.31	15	3.33
Jun 11 - Jun 17	16	4.50	15	3.00
Aug 3 - Aug 25	15	0.20	16	2.69
Overall CPT		1.83		2.41
John Day forebay				
Apr 19 - May 11	11	2.36	15	0.73
May 23 - Jun 8	12	8.50	15	1.73
Jun 21 - Jul 1	12	4.75	13	1.85
Aug 17 - Sep 2	8	5.25	16	2.29
Overall CPT		5.22		1.65
John Day tailrace				
Apr 14 - Apr 20	0		16	0.31
Jun 1 - Jun 22	17	1.65	15	1.40
Jul 5 - Jul 21	0		15	0.67
Aug 31 - Sep 23	0		14	0.21
overall CPT		1.65		0.65

Apparent Abundance of Prey Fishes

Twenty-one taxa of prey fish (<250 mm) representing eight families were collected during prey sampling in John Day Reservoir and tailrace with bottom gill nets, beach seine, boat electroshocker, and minnow traps (Table 28). All taxa were collected with boat electroshocker. Twenty taxa were collected with beach seine, 17 with bottom gill nets, and three with minnow traps. Catch of prey fishes with the beach seine was highest, comprising 56.3% of the total. Prey fishes collected with boat electroshocker, bottom gill nets, and minnow traps comprised 36.1%, 6.6%, and 0.4% of the catch, respectively.

The least selective gears were the beach seine and boat electroshocker (Fig. 5 and 6). Beach seining was most effective in capturing all length groups of American shad and smaller sand roller (<55 mm), chinook salmon (<75 mm), chiselmouth (<85 mm), suckers (<85 mm), northern squawfish (<85 mm), and peamouth (*Mylocheilus caurinus*) (<135 mm).

All length groups of sculpins and larger sand roller (>55 mm), chiselmouth (>85 mm), and suckers (>85 mm) were captured most effectively with the boat electroshocker. Boat electroshocking and beach seining were equally effective in capturing larger chinook salmon (>75 mm), northern squawfish (>85 mm), and peamouth (>135 mm).

Ranks were assigned in order of abundance to fish taxa collected with beach seine and boat electroshocker (Table 291. Ranks assigned by the gears were less variable among the five most commonly collected

Table 28. Catch and percent composition of prey fishes (<250 mm) collected with bottom gill nets (BG), beach seine (BS), boat electroshocker (ES), and minnow traps (MT), John Day Reservoir and tailrace, April to September 1983.

Common name	Scientific name	Gear type BG	BS	ES	MT	Total catch	Percent composition
American shad	Alosa sapidissima	50	1,014	407		1,471	10.7
chinook salmon	Oncorhynchus tshawytscha	9	558	272		839	6.1
rainbow trout	Salmo gairdneri	3	6	39		48	0.3
mountain whitefish	Prosopium williamsoni	4	15	10		29	0.2
chiselmouth	Acrocheilus alutaceus	49	54	210		313	2.3
carp	Cyprinus carpio		8	2		10	<0.1
peamouth	Mylocheilus caurinus	147	447	93		687	5.0
northern squawfish	Ptychocheilus oregonensis	305	1,242	341		1,888	13.8
redside shiner	Richardsonius halteatus	8	18	6		32	0.2
suckers[a]	Catostomus spp.	144	3,999	2,927	1	7,071	51.5
sand roller	Percopsis transmontana	134	328	345		807	5.9
sunfishes[b]	Lepomis spp.	1	4	3		8	<0.1
smallmouth bass	Micropterus dolomieui	1	16	109		126	0.9
largemouth bass	Micropterus salmoides	4	15	2	1	22	0.2
crappies[c]	Pomoxis spp.	3	43	9		55	0.4
yellow perch	Perca flavescens	9	11	16		36	0.3
walleye	Stizostedion vitreum vitreum			7		7	<0.1
sculpins	Cottus spp.	30	26	161	59	276	2.0
Total catch		901	7,804	4,959	61	13,725	
Percent composition		6.6	56.9	36.1	0.4		

[a] Includes largescale sucker (Catostomus macrocheilus) and bridgelip sucker (Catostomus columbianus).
[b] Includes pumpkinseed (Lepomis gibbosus) and bluegill (Lepomis macrochirus).
[c] Includes white crappie (Pomoxis annularis) and black crappie (Pomoxis nigromaculatus).

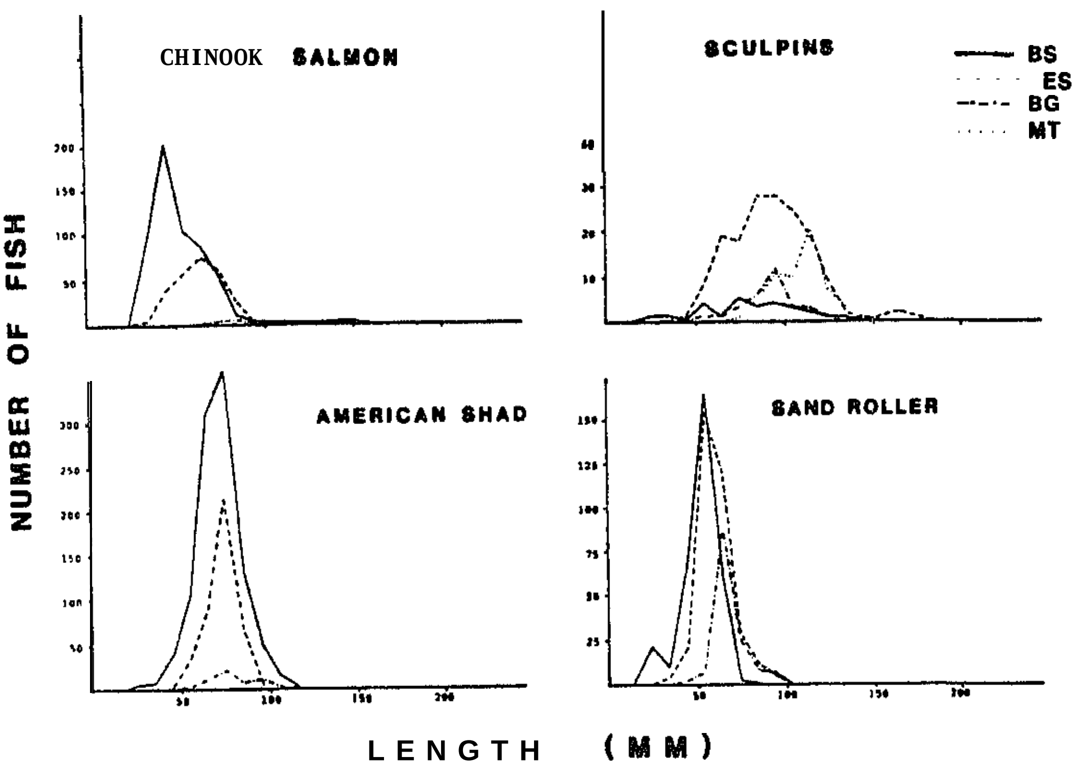

Figure 5: Relative size and species selectivity of beach seine (BS), boat electroshocker (ES), bottom gill nets (BG), and minnow traps (MT) for chinook salmon, American shad, sculpins, and sand roller, John Day Reservoir and tailrace, 1983.

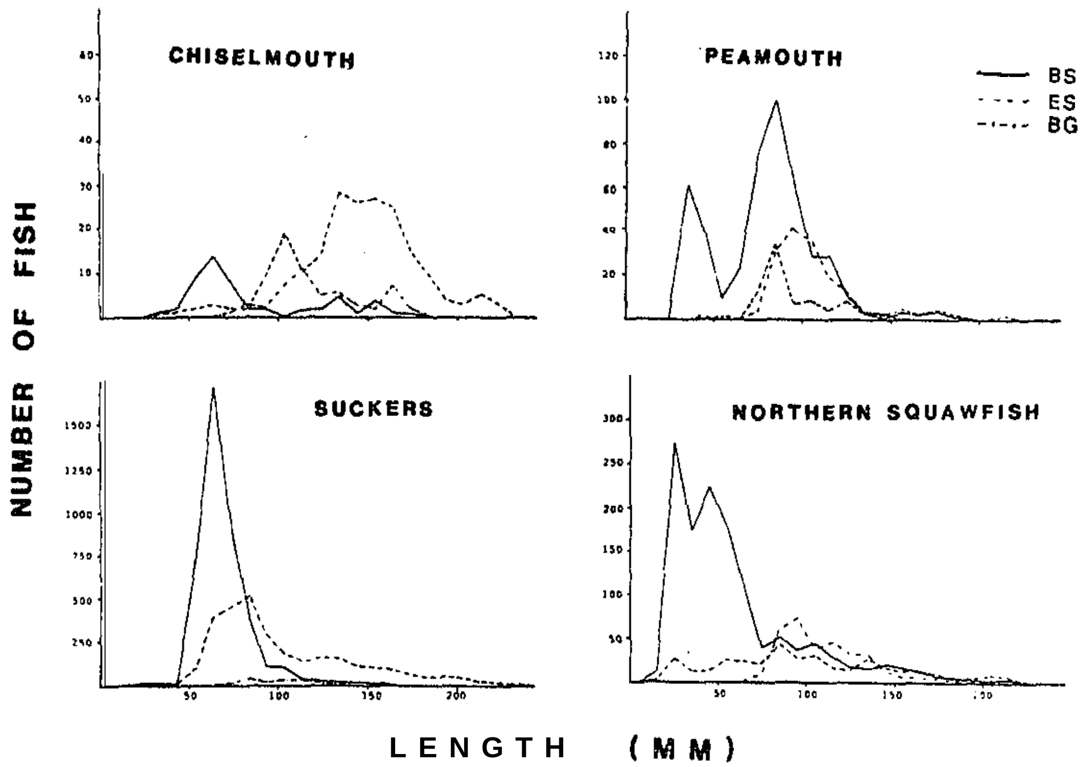

Figure 6. Relative size and species selectivity of beach seine (BS), boat electroshocker (ES), and bottom gill nets (BG) for chiselmouth, suckers, peamoth, and northern squawfish, John Day Reservoir and tailrace, 1983.

Table 29. Rank of abundance and difference in rank (di) for prey fishes collected with beach seine (BS) and boat electroshocker (ES) during four sample periods at McNary tailrace and Irrigon, John Day Reservoir, 1983. Ranks are averages based on ranks assigned to each species during each sample period. Number of sample periods (n) when a species could be ranked by both gears is indicated.

Common name	McNary tailrace (backwater) n	BS	ES	di	Irrigon (main channel) n	BS	ES	di
chinook salmon	3	4.0	3.3	0.7	4	3.3	4.3	1.0
peamouth	4	2.5	3.8	1.3	3	5.0	5.3	0.3
northern squawfish	4	2.0	2.3	0.3	4	2.8	4.3	1.5
suckers	4	1.5	1.3	0.2	4	2.0	1.5	0.5
sand roller	4	5.6	5.9	0.3	3	2.0	1.7	0.3
redside shiner	1	6.5	7.5	1.0				
chiselmouth	1	5.0	6.0	1.0	1	6.0	7.0	1.0
sunfishes	1	9.0	7.5	1.5				
smallmouth bass	1	7.0	3.0	4.0				
largemouth bass	1	6.0	8.5	2.5				
crappies					2	6.5	6.5	0
yellow perch	1	9.0	4.0	5.0				
sculpins	2	9.3	7.3	2.0	1	3.0	7.5	4.0

fish taxa (chinook salmon, peamouth, northern squawfish, suckers, and sand roller). Differences in boat electroshocker and beach seine ranks for these taxa ranged from 0.2 to 1.5 ($\bar{X}$ = 0.64). Differences in ranks by gear for less common taxa ranged from 0.0 to 4.0 ($\bar{X}$ = 2.2).

Catch of prey fishes at various sampling stations in John Day Reservoir and tailrace illustrated differences in spatial distribution for some prey taxa (Fig. 7). Catches of northern squawfish, peamouth, and suckers were highest at McNary tailrace backwater. Sculpins and chiselmouth were more common in the main channel at John Day forebay and tailrace. Catches of sand roller and chinook salmon were highest in the main channel at Irrigon.

Temporal differences in distribution of prey fish were most evident among anadromous species (Appendix Tables 1 and 2). Catch of chinook salmon with boat electroshocker and beach seine was highest from the end of April to the beginning of June. American shad were most abundant in September at John Day tailrace.

Resident prey taxa exhibited more subtle changes in temporal distribution. Catches of northern squawfish with electrofishing gear and beach seine at McNary tailrace backwater were lowest in April and increased steadily through August. Conversely, catch of suckers was highest during April and May, and lowest in August. Catches of sand roller with beach seine and boat electroshocker in the main channel at Irrigon were relatively high during April, May, and June and then decreased substantially during the August sample. Other prey taxa exhihited no apparent temporal distribution pattern.

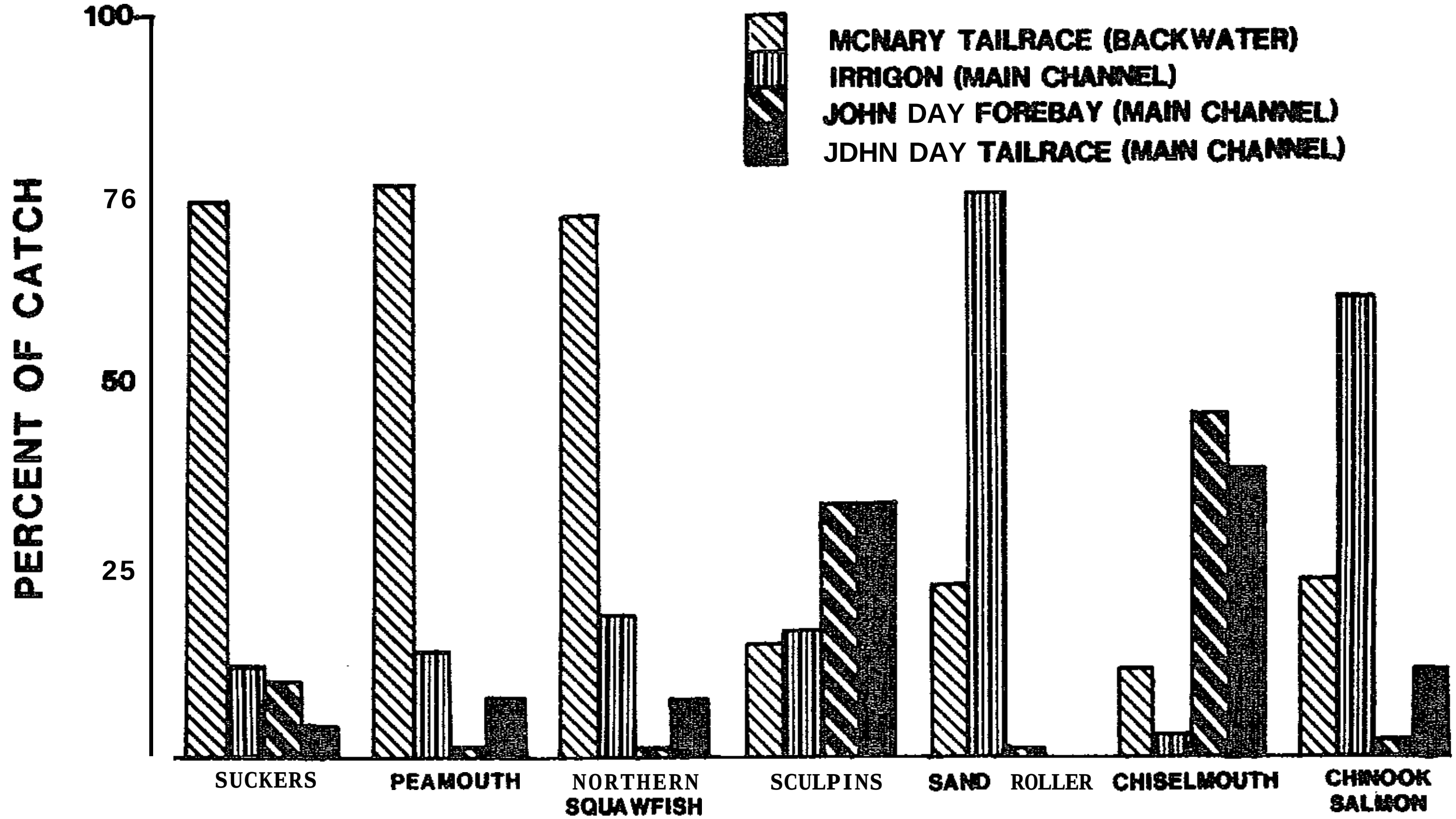

Figure 7. Percent catch of suckers, peamouth, northern squawfish, sculpins, sand roller, chiselmouth, and chinook salmon by station, John Day Reservoir and tailrace, 1983.

Body Length Regressions

Relationships between fork length and other selected body and bony part lengths were determined for chinook salmon ranging in length from 34 to 184 mm (Table 30). Coefficients of determination (r^2) ranged from 0.979 to 0.999. Body lengths predicted fork length best, followed by cleithrum, dentary, and opercle measurements. The relationship between fork length and weight was calculated to be: total weight (g) = 0.000012633 x fork length$^{2.98}$ (r^2 = 0.989).

Northern Squawfish Digestion Experiments

A total of 162 northern squawfish were sampled in experiments to determine digestion of salmonid prey over time. Experimentation was primarily conducted at water temperatures of 10 C, using small and medium prey, and 20 C with medium prey (Table 31). At most, three data points were obtained at each selected time interval for each combination of water temperature, prey size, and predator size.

Table 30. Regression equations describing relationships between fork (Fl) length (mm) and opercle (Op), dentary (De), cliethrum (Cl), nape to tail (Nt), standard (Sl), and total length (Tl) for juvenile chinook salmon ranging from 34 to 184 mm in total length.

Equation	r^2	n
Fl = 13.81 x Op + 2.36	0.979	50
Fl = 10.30 x De - 12.02	0.981	52
Fl = 10.07 x Cl - 8.42	0.985	52
Fl = 1.19 x Ntt 7.40	0.993	50
Fl = 1.05 x Sl + 2.23	0.999	53
Fl = 0.9413 x Tl - 2.16	0.999	53

Table 31. Numbers of small (250-349 mm), medium (350-400 mm), and large (>400 mm) northern squawfish sampled during digestion experiments using small (4-10 g), medium (15-30 g), and large (>35 g) juvenile salmonid prey, 1983.

Water temp & prey sizes	Predator size (Fl) Small	Medium	Large	Total
10 C				
Small	16	11	10	37
Medium	16	13	19	48
Large	1	5	10	16
15 C				
Small	0	0	0	0
Medium	7	5	6	18
Large	0	0	0	0
20 C				
Small	9	4	1	14
Medium	14	10	5	29
Large	0	0	0	0

DISCUSSION

Diets and abundance of northern squawfish, walleyes, and smallmouth bass in 1983 were generally similar to 1982, while changes in collection techniques for channel catfish made comparisons between years inappropriate. Northern squawfish remained abundant at tailrace and forebay stations in 1983. In these areas, the percent by weight of juvenile salmonids in the diet was generally higher among medium (100-249 mm) and large northern squawfish ($\geq$ 250 mm) than at Irriqon; one notable exception was the relatively high percent by weight among medium northern squawfish from Irriqon in June, 1983 (61.2%).

As in 1982, walleyes were commonly collected outside boat restricted zones in 1983; none were collected in John Day forebay in 1983. The percent by weight of juvenile salmonids in walleyes was generally higher in 1983 at McNary tailrace than in 1982, particularly in August (1983 = 22.4%, 1982 = 0%). At Irriqon and John Day tailrace the percent by weight of salmonids in walleyes was generally lower in 1983.

Smallmouth bass was the most common predator collected in the study area. Smallmouth bass contained few juvenile salmonids in both 1982 and 1983. The single occasion when juvenile salmonids accounted for more than 5% of the diet by weight was in McNary tailrace during August, 1983.

More than 80% of the channel catfish were collected directly below McNary Dam or at Irrigon: all hut one of the remaining fish were collected at John Day tailrace. The percent by weiqht of juvenile salmonids was high at McNary tailrace in May (59.5%) and June, 1983 (58.8%), and at Irrigon in May, 1983 (42.5%); the weight of juvenile salmonids in channel catfish was consistently low at John Day tailrace in 1983.

The beach seine and boat electroshocker were generally most effective for catching the widest range of sizes and taxa of prey fishes. Differences in catch occurred among stations.

Work is being conducted to obtain coefficients for predictive equations needed to calculate consumption. We now have regressions to back-calculate original weight from length of bony parts. We are progressing toward the completion of experiments to estimate digestion rates for northern squawfish. Emphasis in 1984 will he on collecting data in categories where there are presently no data points, at 15 C using small and large prey and at 20 C using large prey.

The sampling plan used in 1983 to collect predators proved effective in capturing more fish of each species over shorter time intervals. We continued this approach in 1984.

To improve estimates of apparent prey abundance, efforts in 1984 will he directed towards more extensive sampling with the most effective gear types. This will be accomplished by increasing beach seine and electroshocking effort to include hackwater and main channel habitats at McNary tailrace and Irrigon.

REFERENCES

Gray, G.A., G.M. Sonnevil, H.C. Hansel, C.W. Huntington, and D.E. Palmer. **1984.** Feeding activity, rate of consumption, daily ration, and prey selection of major predators in the John Day Pool. Annual Report to the Bonneville Power Administration. Naational Fishery Research Center, Cook, Washington, USA.

APPENDIX

Appendix Table 1. Mean catch per haul of prey fishes ($\leq$ 250 mm) collected with beach seine by sampling station, John Day Reservoir and tailrace, April to September, 1983.

	McNary tailrace					Irrigon					John Day tailrace					
Common name	Apr 4 Apr 21	May 5 May 20	Jun 4 Jun 22	Aug 1 Aug 25	Mean	Apr 5 Apr 22	May 6 May 24	Jun 11 Jun 17	Aug 3 Aug 25	Mean	Apr 14 Apr 20	Jun 1 Jun 22	Jul 5 Jul 21	Aug 31 Sep 23	Mean	Overall mean
American shad	-	-	-	0.33	0.08	-	-	-	-	-	-	-	-	337.67	84.42	28.17
chinook salmon	1.67	26.33	7.33	-	8.83	8.67	74.33	41.0	0.33	31.08	21.67	4.67	-	-	6.59	15.50
rainbow trout	-	-	-	-	-	1.0	-	-	-	0.25	0.33	-	0.67	-	0.25	0.17
mountain whitefish	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	1.25	0.42
chiselmouth	1.0	5.0	4.0	-	2.50	-	-	1.0	-	0.25	-	6.0	1.0	-	1.75	1.50
carp	-	-	-	2.67	0.67	-	-	-	-	-	-	-	-	-	-	0.22
peamouth	18.33	38.0	31.0	27.67	28.75	2.33	1.33	13.0	-	4.17	12.0	0.67	2.0	2.67	4.34	12.42
northern squawfish	11.67	85.33	84.33	132.0	78.33	19.0	4.33	29.0	22.67	18.75	8.0	4.0	11.0	2.67	6.42	34.50
redside shiner	0.67	2.0	0.33	-	0.75	-	-	-	-	-	1.67	1.0	-	0.33	0.75	0.50
suckers[a]	977.0	108.33	118.33	16.67	305.08	45.33	5.67	44.33	8.0	25.83	2.67	4.0	2.0	0.67	2.34	111.08
sand roller	0.67	18.67	3.0	7.0	7.34	10.0	11.67	58.33	-	20.0	-	-	-	-	-	9.11
sunfishes[b]	-	0.33	0.33	0.67	0.33	-	-	-	-	-	-	-	-	-	-	0.11
smallmouth bass	-	-	0.67	3.67	1.09	-	-	-	-	-	-	0.33	-	0.67	0.25	0.45
largemouth bass	-	-	-	4.33	1.08	-	-	0.33	-	0.08	0.33	-	-	-	0.08	0.42
crappies[c]	-	-	1.33	10.0	2.83	-	-	0.33	0.67	0.25	0.33	0.33	0.33	1.0	0.50	1.19
yellow perch	-	-	2.67	1.0	0.92	-	-	-	-	-	-	-	-	-	-	0.31
sculpins	-	1.33	0.33	0.67	0.58	-	-	-	1.0	0.25	2.33	1.33	0.67	1.0	1.33	0.72

[a] Includes largescale sucker and bridgelip sucker.
[b] Includes pumpkinseed and bluegill.
[c] Includes white crappie and black crappie.

Appendix Table 2. Mean catch per transect of prey fishes (≤ 250 mm) collected with electrofishing gear by sampling station, John Day Reservoir and tailrace, April to September, 1983.

Common name	McNary tailrace					Irrigon					John Day forebay					John Day tailrace					Overall mean
	Apr 4 Apr 21	May 5 May 20	Jun 4 Jun 22	Aug 1 Aug 25	Mean	Apr 5 Apr 22	May 6 May 24	Jun 11 Jun 17	Aug 3 Aug 25	Mean	Apr 10 May 11	May 23 Jun 8	Jun 21 Jul 1	Aug 17 Sep 2	Mean	Apr 14 Apr 20	Jun 1 Jun 22	Jul 5 Jul 21	Aug 31 Sep 23	Mean	
American shad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	135.67	33.92	8.48
chinook salmon	1.0	22.67	5.0	-	7.17	2.0	21.0	26.0	0.33	12.33	3.33	2.33	0.67	-	1.58	1.0	4.67	0.33	0.33	1.58	5.67
rainbow trout	1.33	-	-	-	0.33	-	-	-	-	-	5.0	5.0	-	-	2.50	0.67	0.67	0.33	-	0.42	0.81
mountain whitefish	-	-	-	-	-	0.67	-	0.33	-	0.25	-	-	-	-	-	-	0.67	1.67	-	0.59	0.21
chiselmouth	-	-	0.67	0.33	0.25	-	0.33	1.0	-	0.33	14.33	9.0	2.0	9.67	8.75	8.67	12.0	10.0	2.0	8.17	4.38
carp	-	0.33	-	-	0.08	0.33	-	-	-	0.08	-	-	-	-	-	-	-	-	-	-	0.04
peamouth	2.33	12.67	3.33	1.0	4.83	1.67	1.0	4.67	2.67	2.50	-	-	-	-	-	1.0	0.33	-	0.33	0.42	1.94
northern squawfish	1.33	10.67	18.33	31.67	16.25	0.33	10.0	7.67	19.67	9.42	-	-	-	-	-	0.67	2.0	7.0	1.33	2.75	7.10
redside shiner	0.33	-	-	0.33	0.17	-	-	-	-	-	-	-	-	0.33	0.08	-	0.67	-	0.33	0.25	0.12
suckers[a]	52.0	352.0	101.33	19.33	131.17	35.33	15.33	47.67	70.67	42.25	42.33	55.67	30.0	77.67	51.42	1.33	58.0	14.33	2.67	19.08	60.98
sand roller	0.33	9.67	1.33	0.67	3.0	32.67	25.67	35.67	8.67	25.67	0.33	-	-	-	0.08	-	-	-	-	-	7.19
sunfishes[b]	-	1.0	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06
smallmouth bass	0.67	1.0	-	1.67	0.84	-	3.0	2.0	1.0	1.5	6.0	4.33	3.0	6.0	4.83	-	3.33	3.67	0.67	1.92	2.27
largemouth bass	-	-	-	0.33	0.08	-	-	-	0.33	0.08	-	-	-	-	-	-	-	-	-	-	0.04
crappies[c]	-	-	-	-	-	-	0.33	-	1.33	0.42	-	-	-	1.0	0.25	-	-	-	0.33	0.08	0.19
yellow perch	-	0.33	-	1.67	0.50	0.33	0.33	-	2.67	0.83	-	-	-	-	-	-	-	-	-	-	0.31
walleye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	1.0	0.33	-	0.58	0.15
sculpins	-	2.0	-	0.33	0.58	-	1.67	0.67	1.0	0.84	1.67	5.0	7.0	10.67	6.09	0.33	14.67	5.33	3.33	5.92	3.35

[a] Includes largescale sucker and bridgelip sucker.
[b] Includes pumpkinseed and bluegill.
[c] Includes white crappie and black crappie.

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